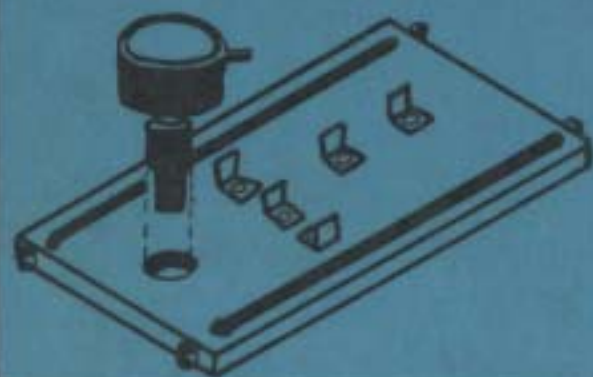
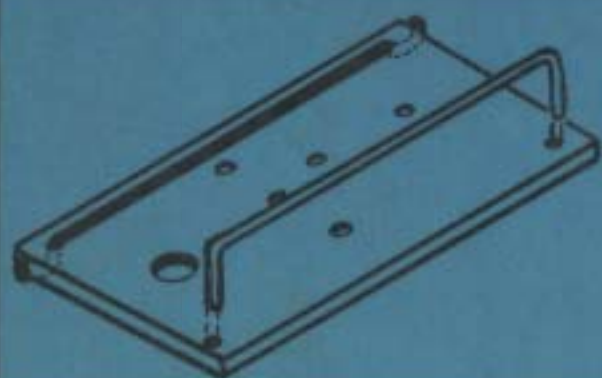
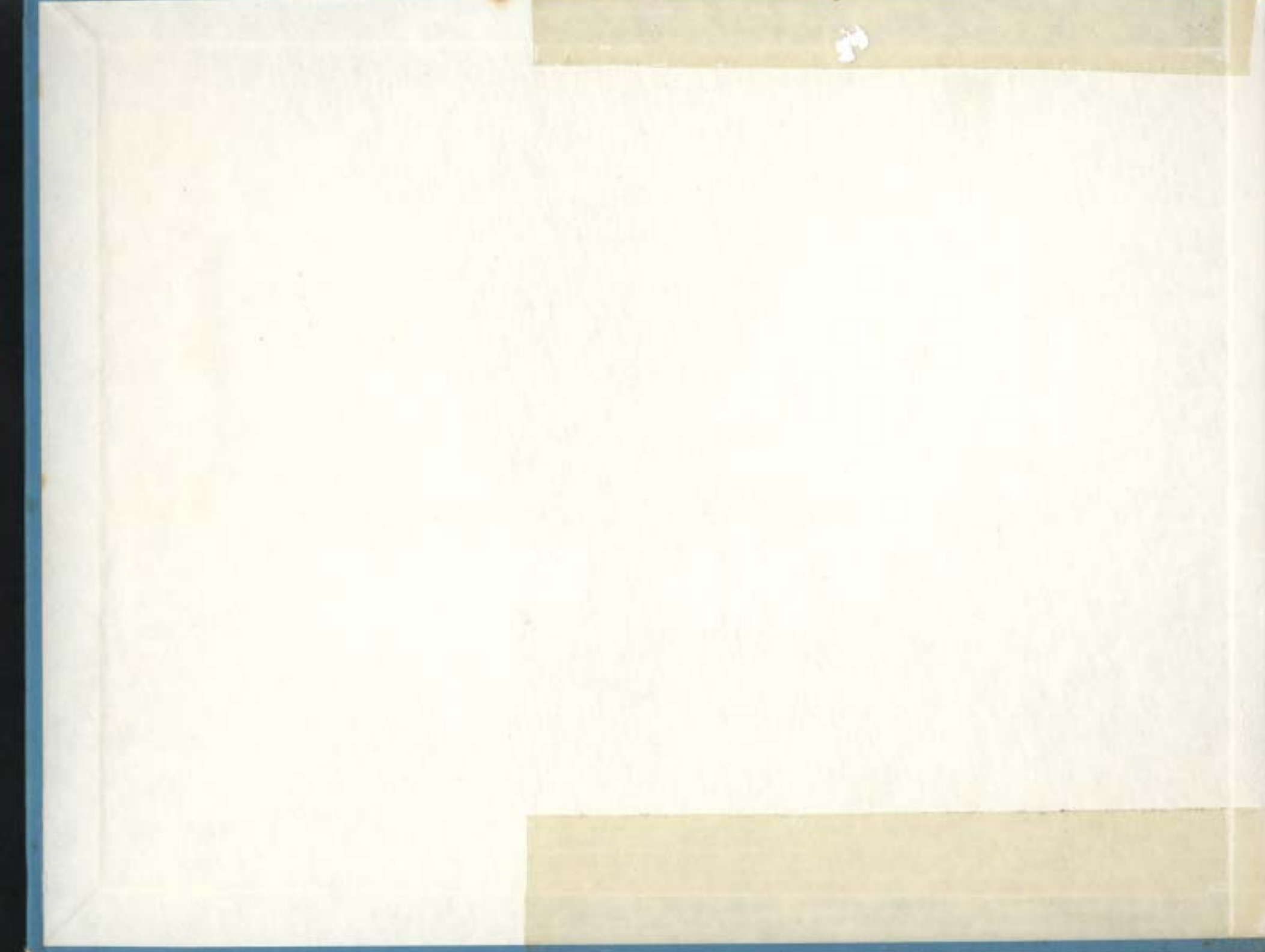


SEE
AND
MAKE
SERIES

modern transistor radios

Fully illustrated step-by-step
by
R. H. WARRING





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2

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First published 1976

ISBN 0 7188 2160 2

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Printed in Great Britain by
Butler & Tanner Ltd, Frome and London



Lutterworth Press • Guildford and London

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INTRODUCTION

This book tells you, step-by-step, how to make nine different simple transistor radios, each of which should give good listening results through headphones, or a deaf-aid earpiece. Two additional *output* circuits are then given, either of which, when coupled to any of these circuits, will convert the original circuit to working a loudspeaker.

All the circuits have been kept simple, using inexpensive and readily available components throughout. Some of the circuit designs reduce the number of components used to a minimum. One or two are rather more elaborate—and it will be interesting to compare the difference in results achieved.

No previous knowledge of radio or electronics is needed to complete any of the circuits, and the step-by-step instructions are illustrated pictorially—not by the more usual 'theoretical' circuit diagrams using symbols for components, which beginners often find confusing. However, circuit diagrams of all the designs are given separately on pages 30 and 31. They are not necessary for building the sets, but you should find them instructive for double-checking connections, and also for relating component layout plans to theoretical diagrams.

If you are a complete beginner, then it is recommended that you first read the companion volume in the 'See-and-Make' series—*Modern Crystal Sets*. This explains what the different types of radio components are, how they are marked and identified, and how they are used in simple radio circuits. It also gives instructions, in well-defined stages, on making good soldered joints—essential for satisfactory connections in any radio set. There is also a lot of useful information in this companion volume on how to set up an efficient aerial and earth, on which the performance of the simpler radio sets usually depends.

All the circuits described are assembled on a Paxolin panel, fitted with terminal points and a common connecting line, called a bus bar. In each case a full size pattern is given for the circuit panel, together with a separate diagram showing the positioning and connection of all the components. The actual size and shape of the components may vary somewhat from those drawn, particularly in the case of resistors and capacitors. The same value of resistor or capacitor, in different

makes, can differ in size.

All the components used should be bought new—simply order them by the value or type given in the components list for the circuit. Ask for miniature (or sub-miniature) resistors and capacitors—not the much more bulky old-fashioned types (although these will work equally well, if correct value).

Resistor values are denoted by coloured rings (the resistor colour code is explained in *Modern Crystal Sets*). You need not bother about this since the colour code is given against each resistor in the components lists. You *order* a resistor by the *value* required. Then when it comes to identifying a particular resistor, look up the colour code in the components list. This refers to the colour of the rings on the body of the resistor, starting with the ring nearest one end.

Transistors are ordered by type code (normally letters followed by a number). You should be able to obtain all the transistor types specified, but equivalents or near-equivalents can be used (your supplier can advise you about suitable equivalents, if necessary). Transistors have three leads—the base (b), emitter (e) and collector (c). Diagrams are included in the various circuit plans showing how to identify these three leads.

Capacitor values are marked on the body of the capacitor, so you will have no trouble identifying these.

Unless stated otherwise, only *high impedance* headphones or a *high impedance deaf-aid earpiece* will work in the circuits.

BUILDING TIPS

Follow the step-by-step instructions for each circuit in the order given. These are designed to make it as easy as possible to assemble the circuit with correct connections. However, the usual cause of a circuit not working is a wrong connection—so check all connections after each stage—and again when you have finally completed the circuit.

All joints must be soldered, and each soldered joint must be a good one. 'Dry' soldered joints—they look dull and speckled—are nearly always bad connections. Poor soldered joints are the second most common cause of a circuit not working.

When soldering transistors into the circuit, leave the ends quite long (at least 2.5 cm). Hold each lead in turn with pliers when soldering in place. The jaws of the pliers will soak up the heat from the iron which otherwise could travel up the lead into the transistor body and damage it.

On all the circuits an aerial wire and an earth connecting point are shown. The aerial should be a long length of thin insulated wire, taken up in a vertical direction as far as possible. A good 'earth' point is a cold-water pipe (metal, not plastic). Scrape the pipe clean and clamp on the bared end of a length of insulated wire. Connect the other end of this earth lead to the 'earth' wire point on the set (always the bottom bus bar).

Several of the circuits described will work well without an external aerial and earth connection. This is noted in the instructions. However, in areas where radio reception is poor, connecting a good external aerial and earth will always improve reception.

For simplicity, the terminal points on the radio circuits are formed by 6BA brass screws, which are easy to solder to, provided the screws are cleaned with fine emery paper first. You can use soldering tags instead, fastened to the same points on the panel with eyelets or small rivets (as described in the loudspeaker output circuits on pages 24–27).

The standard panel material is 1.5 mm thick Paxolin. This is obtainable in various sizes. A 30 cm square will be enough for making most of the panels you will require. Paxolin can be cut to size with a fine hack-

saw. Clean up the edges with emery paper or a fine, flat file.

To drill holes in Paxolin, first 'spot' the centre of the hole with a centre punch, tapping the end of the punch with a hammer. This will prevent the drill from skidding across the surface as you start to drill. Use new or resharpened drills in a hand drill or a power drill for drilling Paxolin.

Bus bars are made from $\frac{1}{16}$ " diameter tinned copper wire, cut to a suitable length. Bend the two ends at right angles, pass through the bus bar holes in the panel and then turn up the ends of the wire to hold in place.

The circuits show connecting points for the battery. If using a PP3 battery, solder leads to these connecting points, with press studs at the free ends. Press the studs on to the battery to switch 'on' and remove one stud (or both) to switch 'off'. If you are using pen-cells, fit the batteries into a battery box, wired to the battery connecting points. Either fit an on-off switch in one lead, or fit and remove a cell in the battery box to switch 'on' and 'off' respectively.

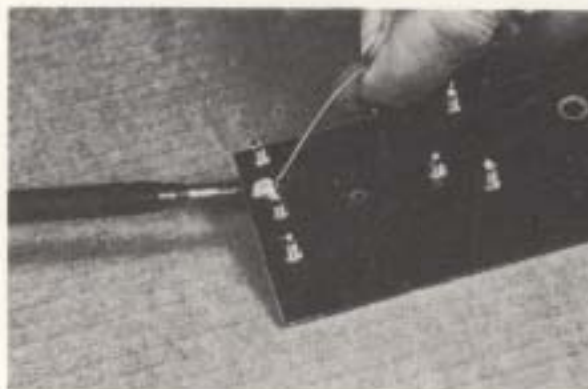
SOLDERING

Wiring connections made in electrical circuits must be soldered for best results. Making soldered joints is quite simple if you use the correct equipment, i.e. a 10-, 15- or 20-watt (mains) soldering iron and multi-cored solder. The photographs on the page opposite will be helpful, but remember to allow the iron to come up to full heat before use and ensure that all joints are 'bright clean' when you start. A good joint should take about 3 seconds to complete; if heated excessively, damage may occur to the components. (Further tips on soldering are contained in *Modern Crystal Sets*.)

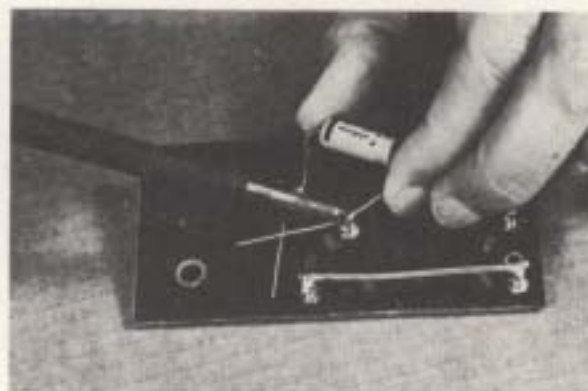
MODERN TRANSISTOR RADIOS



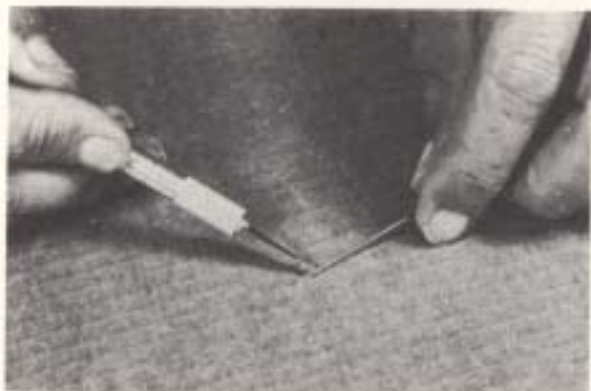
1. 'Tinning' the tip of the iron. When the iron is hot enough for use the solder will melt freely when touched on the tip.



2. 'Tinning' the 6BA terminal screws. Hold iron against top of screw. When heated up sufficiently, touch the screw with solder. Tin each screw in turn.



3. Technique for soldering 'bus bar' and component leads in place. Hold iron in place to heat up joint, then touch with solder, which should melt and run freely to complete joint.



4. If component leads are not 'bright clean', a poor solder joint is likely. Clean leads if necessary by scraping carefully with a modelling knife, the cleaned component lead can then be 'tinned' with the tip of the iron.

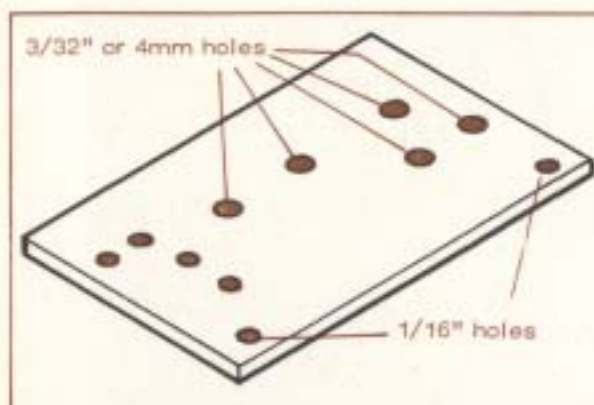


5. With a lead tinned in this way (4), the joint can be completed by holding the lead in place and applying the iron under the joint until the solder melts. Always hold a component in place until the joint has set properly (i.e. has solidified).

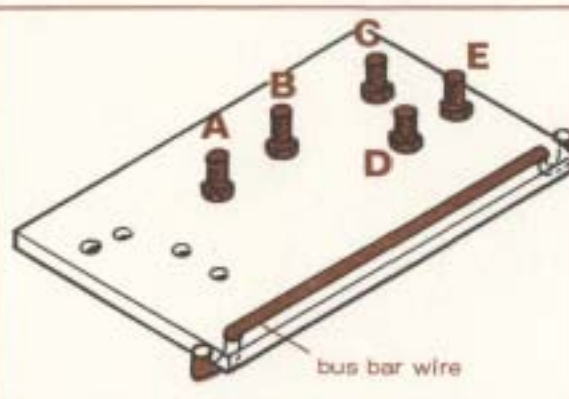


6. When soldering transistors it is a good idea to grip the lead being soldered with flat nose pliers. This will prevent excess heat being conducted up the lead to the body of the transistor, which could be damaging.

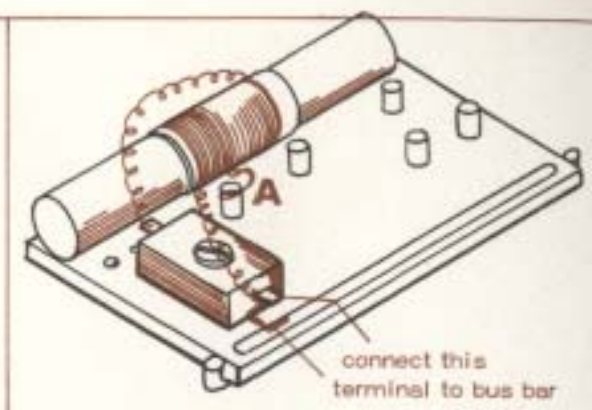
SEE AND MAKE



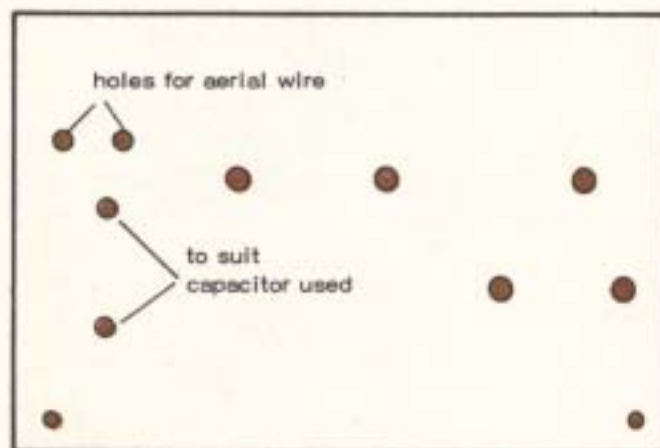
1. The circuit board is a 75 mm × 50 mm (3" × 2") rectangle cut from Paxolin sheet. Use the full size pattern below to mark the various hole positions. Mark the centres with a punch, then drill each hole carefully.



2. Mount five 6BA brass screws in the terminal positions—each being screwed through 2.25 mm ($\frac{1}{8}$ ") holes, or secured in 4 mm holes with nuts (as shown). Fit the bus bar which is a length of tinned copper wire $\frac{1}{16}$ " diameter. Bend up ends of bus bar to secure to the panel.



3. Mount the ferrite rod aerial by sticking the coil down to the panel. Mount the 500 pF tuning capacitor. Connect start and end of coil windings to capacitor terminals, and coil tap to terminal A. Tap comes nearest 'earth' end of coil.

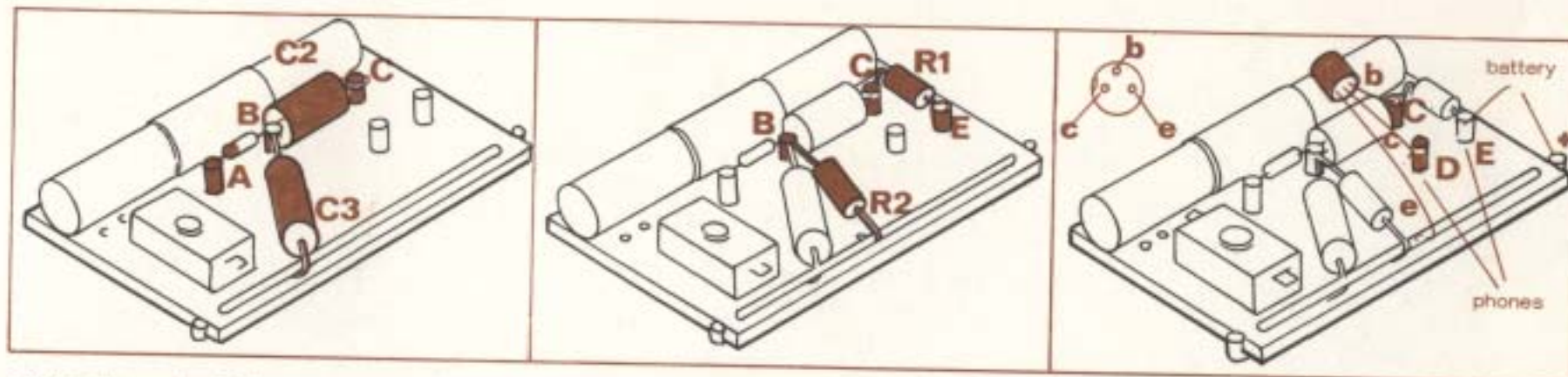


SIMPLE ONE-TRANSISTOR RECEIVER

This receiver uses a ferrite rod aerial 75 mm (3") long, which you can buy ready-finished or make yourself. To make it, cut a 75 mm length of $\frac{3}{8}$ " diameter ferrite rod and fit with a gumstrip sleeve about $1\frac{1}{2}$ " long. Wind on 60 turns of 38 s.w.g. wire, taking out a tapping point at 20 turns. Secure the wire ends with wax or cement.

The circuit is assembled on a Paxolin board (shown full size on left), with 6BA screws for terminal points. Common connections are made to a 'bus bar'. All connections must be soldered. (For beginners, see companion volume *Modern Crystal Sets* for details of how to make aerial coils, and general information about components, and additional information about soldering.)

MODERN TRANSISTOR RADIOS



4. Connect capacitor C2 between terminals B and C. Connect capacitor C3 between B and bus bar. Connect diode between terminal A and terminal B. Note. These components must be assembled the right way round.

5. Connect resistor R1 between terminal C and terminal E. Connect resistor R2 between terminal B and bus bar. It does not matter which way round these are connected, but be sure to use the right values for R1 and R2.

6. Recommended transistor is an OC71 (or equivalent). The diagram shows how to identify the leads (c next to colour spot). Connect transistor lead b to terminal C, c to terminal D and e to bus bar.

Components required for this circuit are:—

Paxolin sheet 1.5 mm thick (cut to 75×50 mm)

Five 6BA brass screws (and nuts if fitted in 3 mm holes)

Ferrite rod aerial (or $\frac{3}{4}$ " diameter ferrite rod and 38 s.w.g. enamelled wire for winding the coil).

Capacitors: C1—500 pF miniature variable capacitor or trimmer

C2—8 or 10 μ F electrolytic

C3—0.001 μ F electrolytic

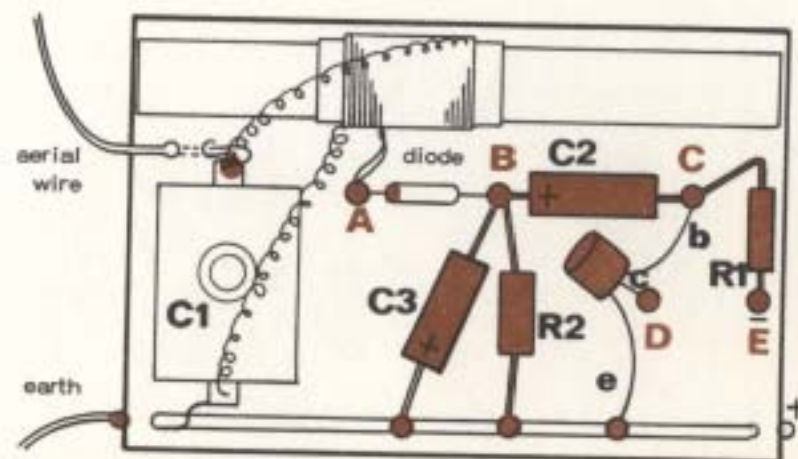
Resistors: R1—1 megohm (colour code brown-black-green)

R2—47 kilohms (colour code yellow-violet-red)

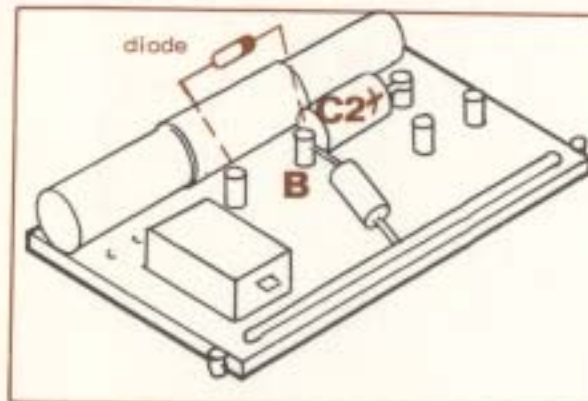
Transistor: OC71 or equivalent (e.g. OA90, AA113, AA116)

Diode: Any germanium diode, e.g. AA113-119, OA47, OA90-91, OA95, etc.

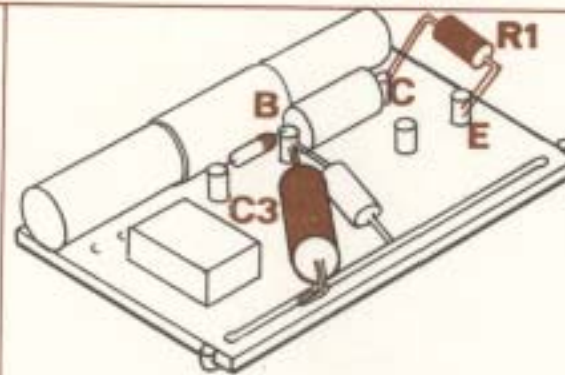
Battery: 1.5 volts up to 9 volts. Note polarity of connection



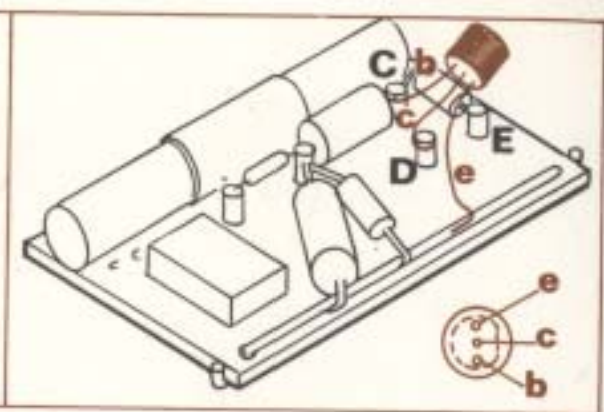
SEE AND MAKE



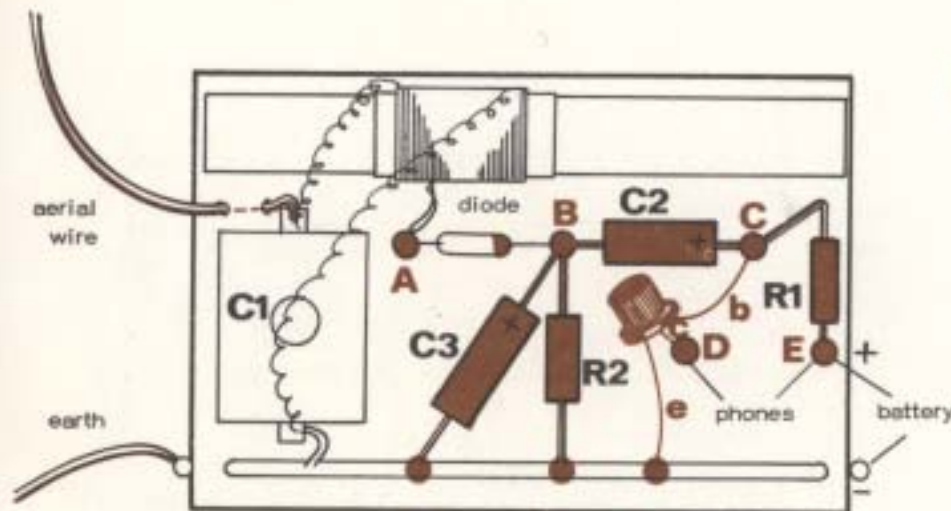
1. Remove the diode, capacitors C1 and C2, and resistor R1 from the circuit built on pages 6 and 7. Replace the diode and capacitor C2 connected the other way round (+ side to terminal B in both cases). Or build up another circuit on a new board.



2. Connect in C3 between terminal B and the bus bar, + end towards B. Connect the new R1 resistor between terminals C and E. Note that different values are used—0.01 μ F for C3 and 470 kilohms for R1 (colour code yellow-violet-yellow).



3. The transistor used is a silicon N-P-N type, such as a 2N2926 or equivalent. Identify the leads from the small diagram. Connect b to terminal C, c to terminal D and e to the bus bar. Be sure to connect the battery the right way round (+ to terminal E).



N-P-N TRANSISTOR RECEIVER

This circuit is the same as that on pages 6 and 7 except that a more powerful silicon N-P-N transistor is used. This has *reversed* polarity, so the battery must be connected the other way round and the diode and electrolytic capacitors (C2 and C3) connections reversed. You can use the same values for all the components, or try new values for C2 and R1.

Use a 9-volt battery, connecting + to terminal E and - to the bus bar. Phones connect to terminals D and E.

This receiver should give you more volume than the previous one. Experiment with different values of C2 and R2 for best results.

SETTING UP YOUR RECEIVER

Unless you live in an area where there are strong local radio signals, you must use an external aerial and earth connected to your receiver. Use a long length of thin insulated wire for the aerial, taken up as high as possible, e.g. through a groundfloor window to an upstairs one. For a good earth connection, connect to a metal cold-water pipe.

There is nothing difficult about setting up your set. First check over all connections to make sure they are correct. As soon as you have connected the battery, the set should sound 'live' in the headphones. Try to tune in to a station by adjusting the variable capacitor. When you hear a station, turn the set from side to side until the station sounds loudest. If you cannot receive more than one station, slide the ferrite rod backwards and forwards through the coil sleeve. This will adjust the tuning range. When you have a position which gives you the most stations, secure the ferrite rod in this position with a dab of wax or balsa cement.

If you can hear nothing at all

The chances are you have made a wrong connection somewhere, or there is one (or more) poorly soldered joint. Check over the circuit connections carefully and re-make any soldered joints which look suspect. One of the components might be faulty, but this is unlikely if you have bought new components. If the battery is connected the wrong way round, however, you can damage components. Always double-check the battery polarity before connecting up.

If you can only get very weak signals

Then probably your aerial is not very efficient. Try using a longer length of wire, strung out in a different way. Also, see if you can find a better earth connection for the set. (The best earth in a house is usually the pipe connecting to the kitchen cold-water tap.)

If stations overlap and interfere with each other

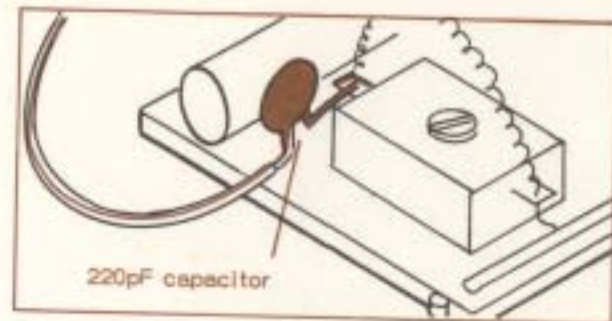
Try reversing the aerial coil connections to the tuning capacitor terminals. This will either make things better—or worse!

If you cannot get more than one station

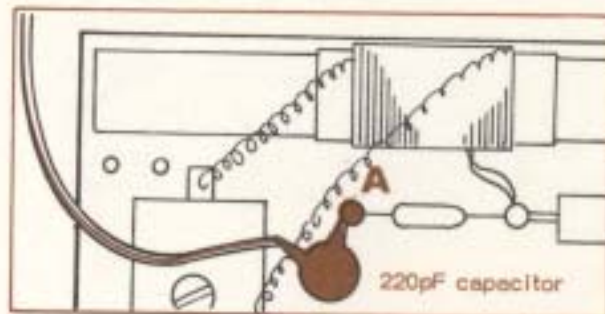
Try a new aerial coil with more (or less) turns, keeping the tapping point at one third of the total number of turns. Better still, if you are using a home-made ferrite rod aerial, replace this with a professionally made one.

Some other things you can try are shown on the right:

- Try connecting in a 220 pF capacitor between the end of the aerial wire and the tuning capacitor. This can work well.
- Try connecting the aerial wire to terminal A in the circuit, either directly or by way of a 220 pF capacitor.
- Try a 0.001 μ F capacitor connected directly across the phones (terminals D and E). This should improve sound quality.



a

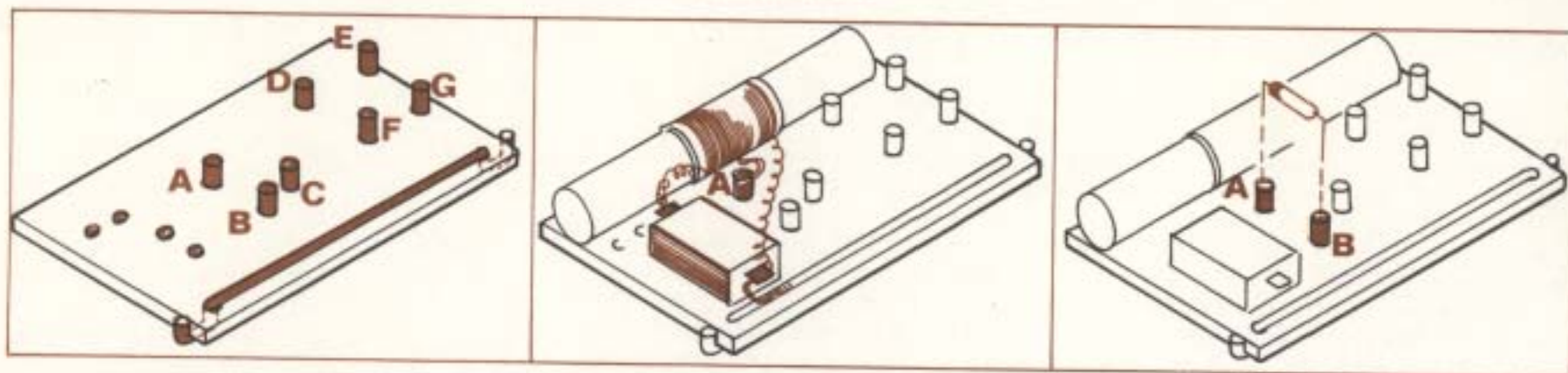


b



c

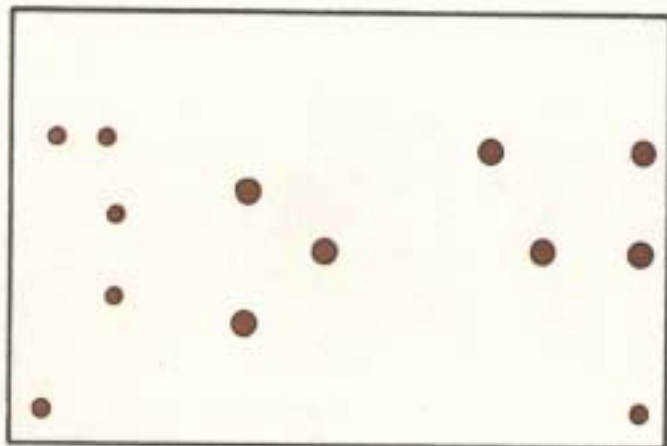
SEE AND MAKE



1. Mark out and drill the seven terminal holes, two bus bar holes, two holes to anchor the aerial wire and two holes for the variable capacitor fixing screws. Fit 6BA brass screws in the terminal holes A, B, C, D, E, F and G. Fit the bus bar of $\frac{1}{8}$ " tinned copper wire.

2. Mount the ferrite rod aerial and the tuning capacitor on the panel. Connect the aerial coil ends to the tuning capacitor terminals, and the tapping point to terminal A. Note the 'tap' comes nearest the 'earth' or bus bar end of the coil. Connect bottom capacitor terminal to the bus bar.

3. The diode is connected between terminals A and B. The polarity must be correct. The plus end of a diode is usually marked with red. This end must connect to terminal A in this circuit. If the diode is the wrong way round the circuit will not work.

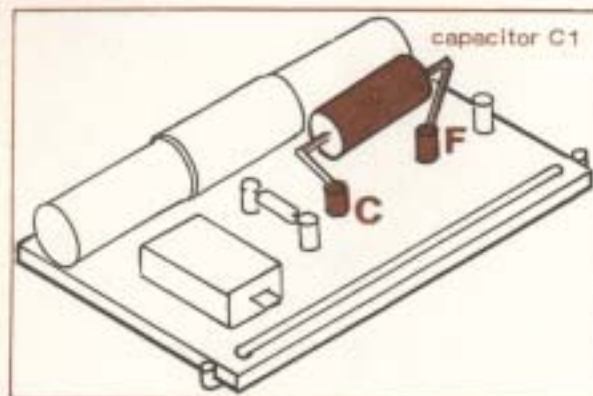


A TWO-TRANSISTOR RECEIVER

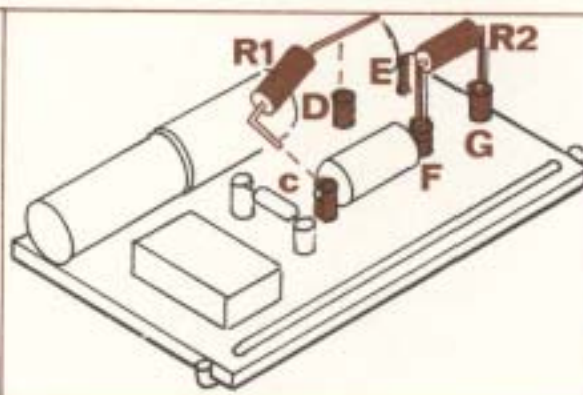
This circuit is based on a diode detector followed by two stages of amplification via transistors TR1 and TR2. The number of components used has been kept to an absolute minimum.

The ferrite rod aerial is the same as that used in the previous circuits. The panel is shown full size on the left with hole positions for the terminals, bus bar wire, aerial wire and mounting points for the tuning capacitor (C1). Check the final wiring up against the component diagram, shown full size on the opposite page. Note that capacitors used may differ in actual shape and size from those shown on this drawing. Points to note are to get the diode and capacitor C2 connected the right way round, and also the battery.

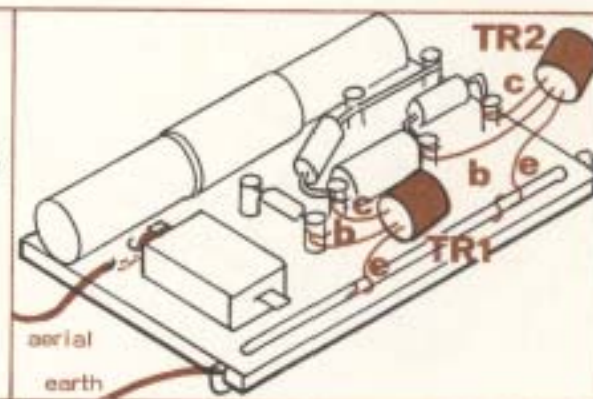
MODERN TRANSISTOR RADIOS



4. This set uses only a single fixed capacitor (C2) which is connected across terminals C and F. This is an electrolytic type and the end marked + must be connected to terminal F. You can also connect a 0.001 μ F capacitor across terminals E and G (not shown in plan, below right).



5. Resistor R1 connects between terminals C and D. By leaving the second lead long it can be taken on to terminal E to connect E to D together. Resistor R2 connects between terminals F and G. It does not matter which way round resistors are connected.



6. Transistor TR1 is an OC71 or equivalent and connects as follows:— c to terminal C, b to terminal B and e to bus bar. Transistor TR2 is an OC71 or OC75. Connections are—c to terminal G, b to terminal F and e to bus bar. Phones link to terminals E and G.

Components required for building this circuit are:—

Ferrite rod aerial (home-made, or bought ready-made).

C1—800 pF miniature tuning capacitor or trimmer capacitor.

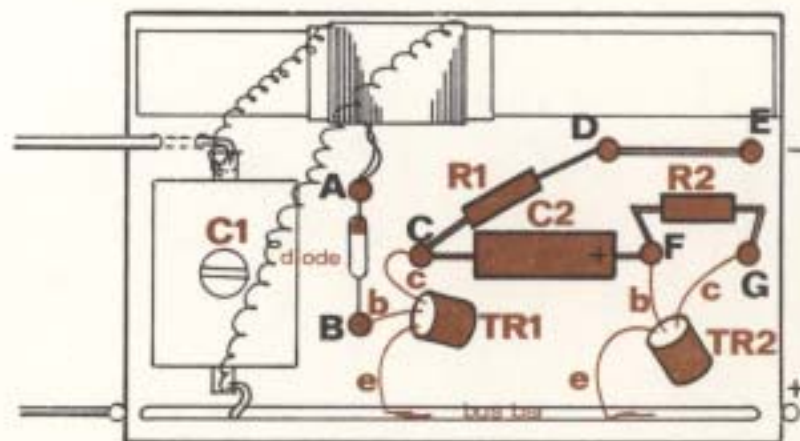
C2—2 μ F electrolytic

R1—220 kilohm resistor (colour code red-red-yellow)

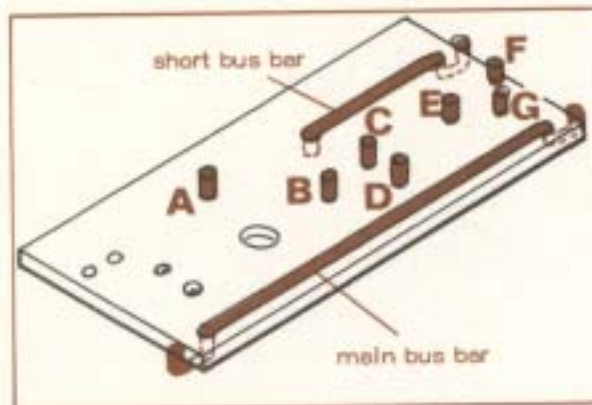
Transistor TR1—OC71 or equivalent

Transistor TR2—OC71 (or equivalent), or OC75 (or equivalent) an OC75 transistor will give better volume.

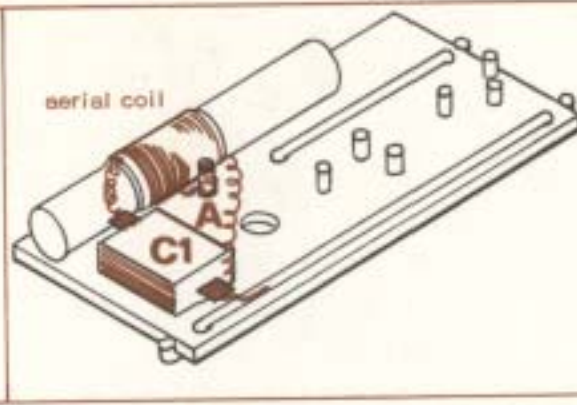
Recommended battery is 3 volt (e.g. two pen-cells connected in series). The circuit should also work on a single 1.5-volt battery. If signal strength is poor, increase the battery voltage to 4.5 volts.



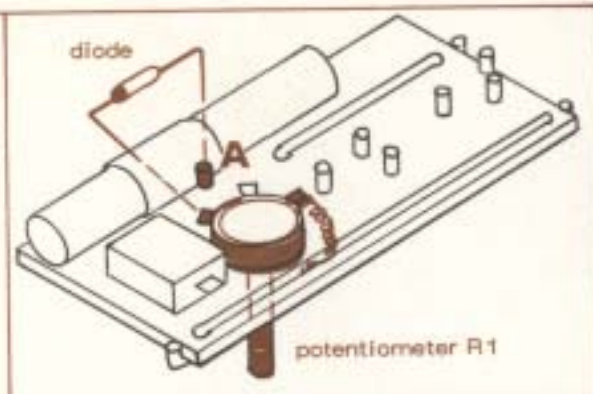
SEE AND MAKE



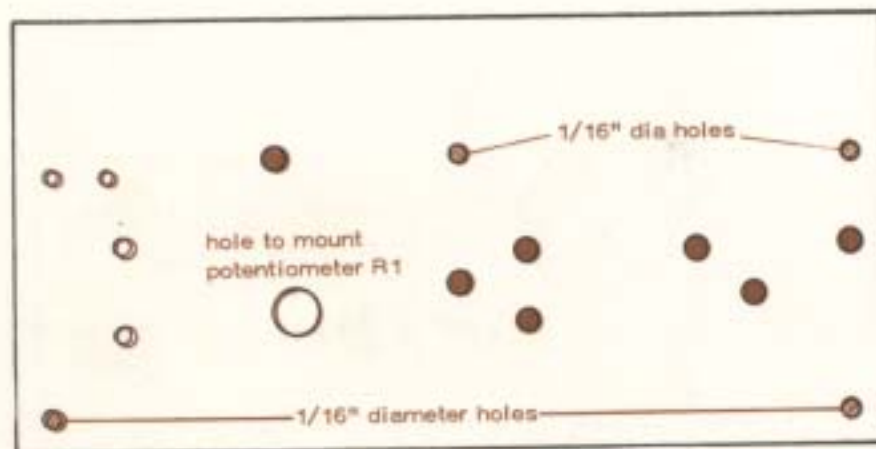
1. Panel size is increased to 100×50 mm (4"×2"). Mark out and drill the terminal holes (solid), bus bar holes (shaded) and other holes from the full size pattern below. Mount terminal screws A, B, C, D, E, F and G. Fit two bus bars.



2. Use the same ferrite rod aerial as before. Mount near one end of the panel as shown. Mount the tuning capacitor C1. Connect the aerial coil ends to the tuning capacitor terminals; and the coil loop to terminal A. Connect bottom leg of tuning capacitor to main bus bar.



3. Assemble the potentiometer R1 through its matching hole in the board, spindle downwards. Connect diode between one end tag of R1 and terminal A (red end to R1). Connect the other end tag of R1 to the bottom bus bar with a short length of insulated wire.

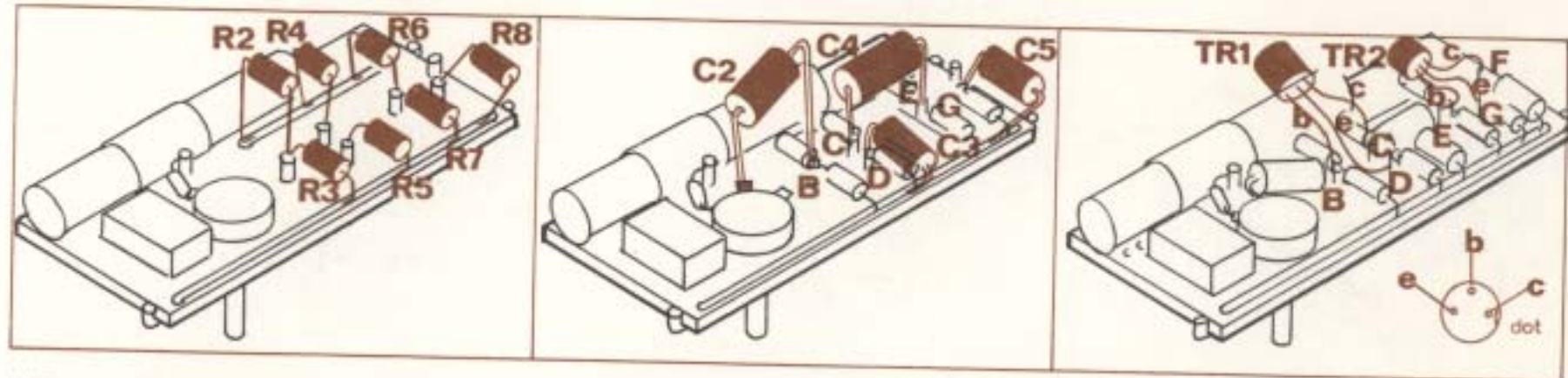


STABILISED TWO-TRANSISTOR RECEIVER

This particular circuit employs capacity coupling between stages, stabilisation of the working point of the transistors and the addition of a volume control. It should be capable of giving good, consistent head-phone reception in most areas. Although a large number of components are involved they are all relatively inexpensive and the circuit is not difficult to construct. It will work off any small dry battery from 3 volts (e.g. two pen-cells) to 9 volts (e.g. a PP3 transistor battery).

Assembly is simplified by fitting the panel with two bus bars. Only seven terminals are then needed, other connections being made to the large components (C1 and R1) and the two bus bars. The top and bottom bus bars are the - and + lines for the circuit, respectively. Phones must be of high impedance type.

MODERN TRANSISTOR RADIOS



4. The seven fixed resistors are connected next. Be sure to identify them correctly (by colour code). R2 connects to B and short bus bar; R4 to C and short bus bar; R6 to E and short bus bar; R3 connects to B and bottom bus bar; R5 to D and bottom bus bar; R7 to E and bottom bus bar; R8 to G and bottom bus bar.

5. Capacitors C2, C3 and C4 must be connected the right way round. C2 connects between centre tag of potentiometer R1 and B (+ to R1); C3 between D and (+ end to bottom bus bar) C4 between C and E (+ end to E); C5 connects between G and (+ end to) bottom bus bar.

6. Finally connect in the transistors. TR1 connections are: b to terminal B; c to terminal C; and e to terminal D. TR2 connections are: b to terminal E; c to terminal F; and e to terminal G. Phones connect to terminal F and top (short) bus bar. Battery connects + to bottom bus bar and - to top bus bar.

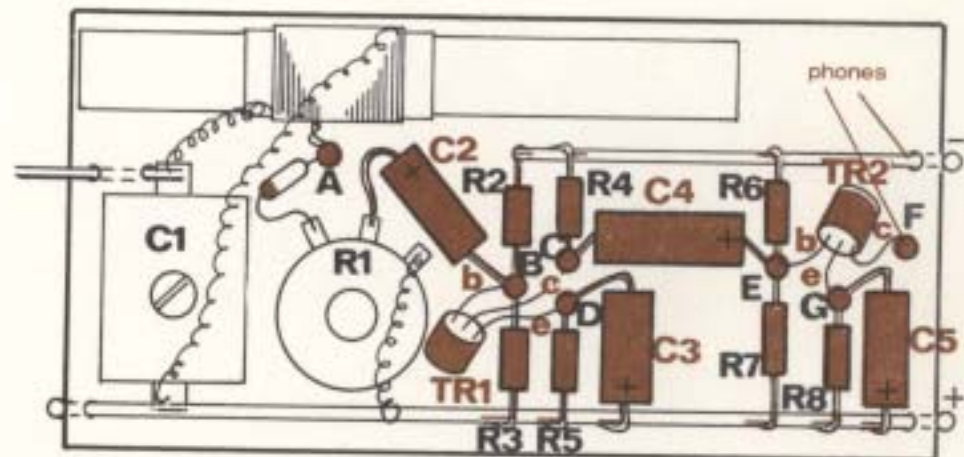
Components for this circuit are:—

Ferrite rod aerial matching C1—220 pF tuning capacitor.

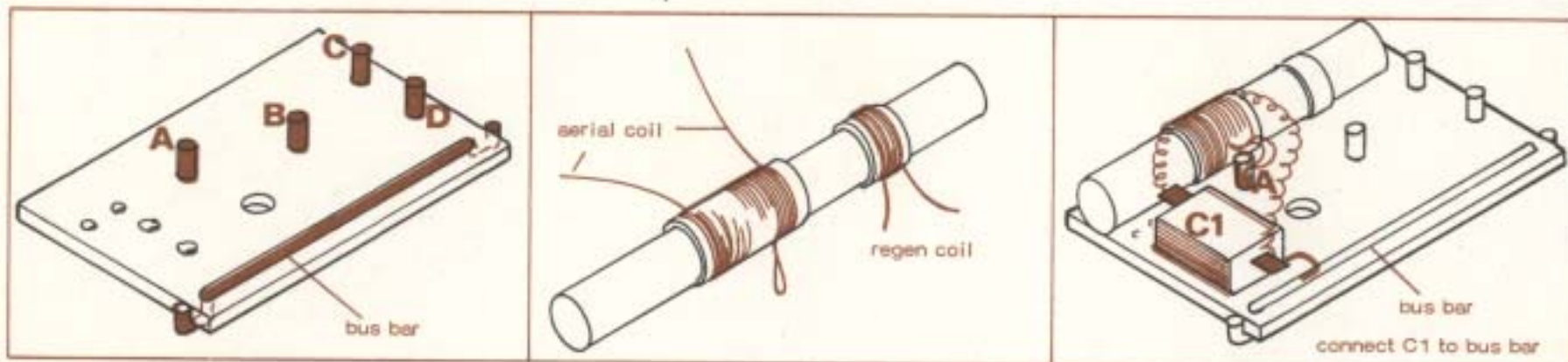
Resistors: R1—5 kilohm miniature potentiometer
 R2—22 kilohms (colour code: red-red-orange)
 R3—2.2 kilohms (colour code: red-red-red)
 R4—1 kilohm (colour code: brown-black-red)
 R5—220 ohms (colour code: red-red-black)
 R6—22 kilohms (colour code: red-red-orange)
 R7—2.2 kilohms (colour code: red-red-red)
 R8—220 ohms (colour code: red-red-black)

Capacitors: C2—0.1 μ F electrolytic
 C3—10 μ F electrolytic
 C4—2 μ F electrolytic
 C5—10 μ F electrolytic

Transistors: TR1—OC71 or equivalent
 TR2—or equivalent



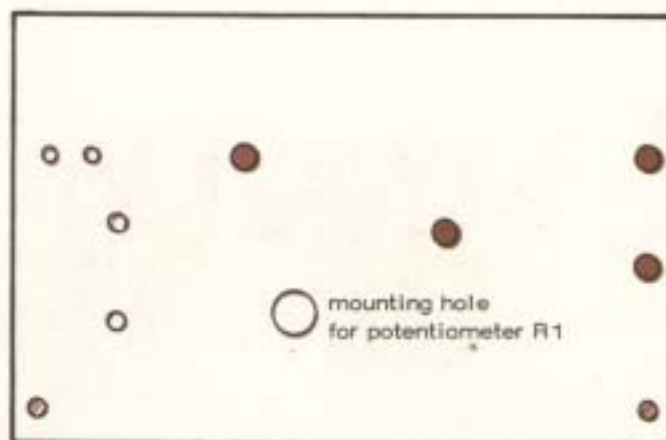
SEE AND MAKE



1. Panel size for this set is 75×25 mm (3"×2"), cut from 1.5 mm Paxolin sheet. Mount four terminal screws in positions A, B, C and D. A bus bar of $\frac{1}{16}$ " diameter tinned copper wire is fitted, as shown. Drill holes for the aerial wire, and for mounting the tuning capacitor.

2. A conventional 60-turn aerial coil is used, tapped at 20 turns. A separate *regen coil* consisting of 6 or 8 turns of 38 s.w.g. enamelled wire is wound on a small sleeve so that it can be slid backwards and forwards along the length of the rod. This adjusts the degree of regenerative coupling.

3. The tuning capacitor (C1) is a 500 pF miniature type. After mounting on the board, connect the aerial coil in the usual way, i.e. start and finish of the winding across the tuning capacitor; and tap to terminal A. The tap must come nearest the end of the coil connected to the bus bar.



ONE-TRANSISTOR REGENERATIVE RECEIVER

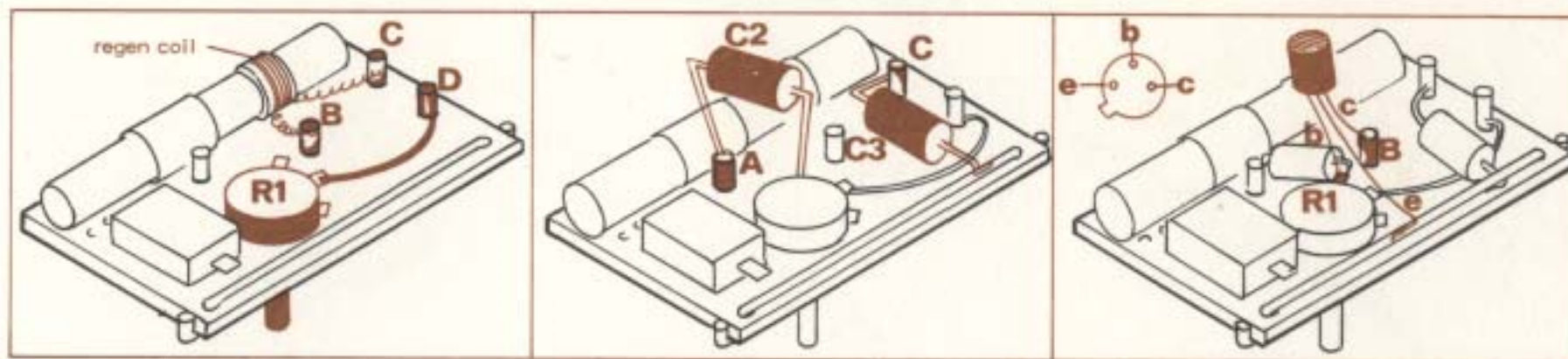
This circuit uses only a single transistor connected up to work in a *regenerative circuit*. This means that part of the amplified signal is fed back to the aerial circuit, resulting in improved *selectivity* and *gain*. It should out-perform any other type of single-transistor receiver, provided you adjust it properly.

The main adjustment is the potentiometer R1. This controls the amount of regeneration. Back off until the circuit oscillates (i.e. squeals). Then turn the other way until optimum results are obtained. Further adjustment can then be made by sliding the regen coil up and down the ferrite rod.

If the set does not work, e.g. will not even 'squeal', then reverse the connections of the regen coil.

This circuit should work best with a 6-volt battery. Be sure to get the polarity

MODERN TRANSISTOR RADIOS



4. The regen coil windings are connected to terminals B and C. You may have to reverse the connections to get the set working. After fitting the potentiometer R1, connect the centre tag to terminal D with a length of insulated wire. Bare the ends of this wire before trying to solder in place.

5. Connect C2 between terminal A and one end tag of the potentiometer R1 (it does not matter which end). Connect capacitor C3 between terminal C and the bus bar. If this capacitor is an electrolytic type, connect the + end to terminal C (the + end will be marked on the capacitor).

6. Here are the transistor connections. Use a silicon N-P-N transistor type BC107, 2N2712 (or equivalent). The smaller diagram identifies the transistor leads. Connect b to the potentiometer tag connected to C2; c to terminal B and e to the bus bar.

right, + side of the battery to terminal D and - side of the battery to the bus bar. Phones connect across terminals C and D.

Components required for this circuit are:—

75 mm ferrite rod aerial, with additional regen coil wound on 500 pF tuning capacitor (C1)

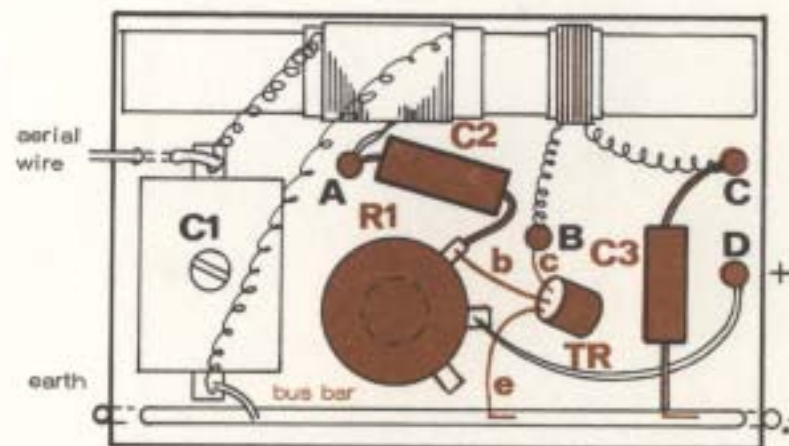
Capacitors: C2—220 pF or 0.001 μ F

C3—0.002 μ F

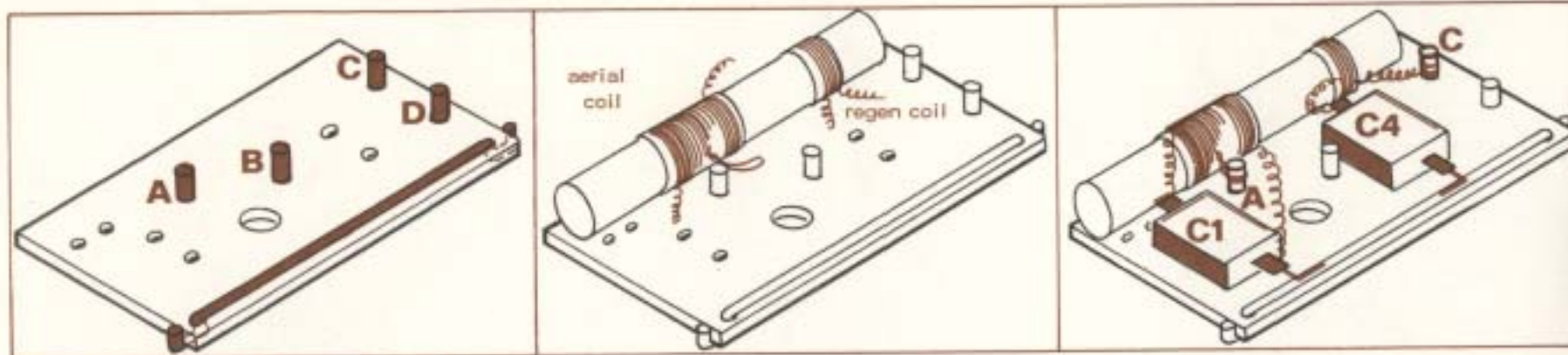
1 megohm miniature potentiometer R1

Transistor: BC107 or 2N2712

In areas where there are good, strong signals, this set may work without an external aerial and earth.



SEE AND MAKE



1. The panel is fitted with four 6BA screw terminals (solid circles on plan below); and a single bus bar (mounted in shaded hole positions below). Drill additional holes for the aerial wire and mounting two 500 pF variable capacitors (see bottom right of plan below for positions).

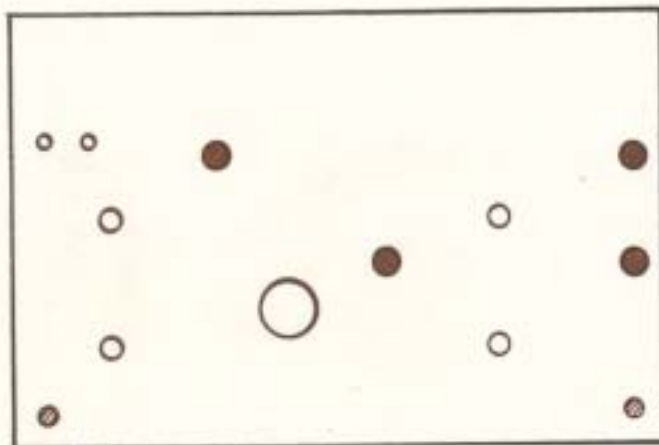
2. A standard aerial coil is used (100 turns tapped at 33 turns wound on a $\frac{3}{8}$ " diameter ferrite rod). A separate regen coil is fitted on to the same ferrite rod. This coil consists of 8 turns of 38 s.w.g. enamelled wire close wound on a paper sleeve. This sleeve should be a tight sliding fit.

3. Aerial coil start and end are connected to terminals of tuning capacitor C1. Tap point of coil connects to terminal A. Connect C1 tag on 'earth' end (nearest tap) to bus bar. Connect the regen coil to one tag of C2 and terminal C. Connect other tag of C2 to bus bar.

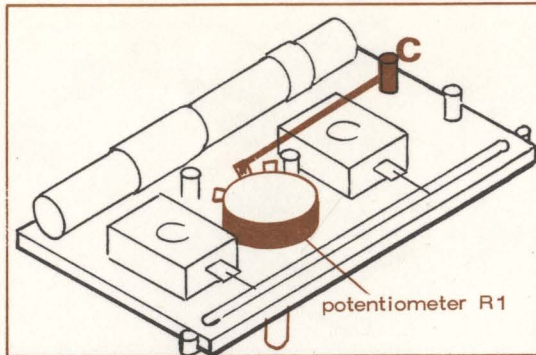
ANOTHER REGENERATIVE RECEIVER

This simple single-transistor circuit employs two 500 pF variable capacitors—one for tuning (C1) and the other (C2) as an adjustable regenerative control. It will also work without C2, in which case regeneration is adjusted by sliding the regen coil up and down the ferrite rod. The idea when adjusting the amount of regeneration, is first to get the set oscillating or 'squealing'. Then reduce the amount of regeneration (either by backing off C2, or sliding the regen coil away from the aerial coil) until oscillation just ceases. The set should then be adjusted for maximum sensitivity.

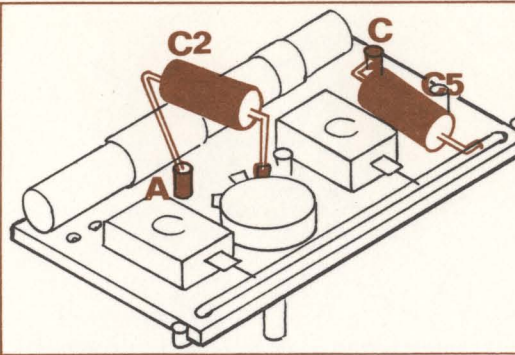
If the set does not work, i.e. cannot be made to oscillate at all, reverse the regen coil connections.



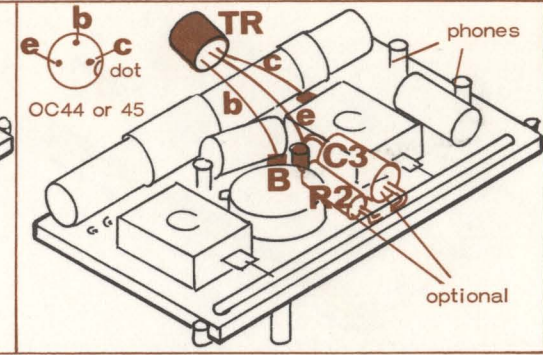
MODERN TRANSISTOR RADIOS



4. Mount the potentiometer (R1) on the board. Connect the centre tag of the potentiometer to terminal C, using insulated wire. Bare the wire ends before trying to solder in place. This component works as a volume control for the circuit.



5. Connect capacitor C2 between terminal A and one end tag on the potentiometer (R1). The other end tag on R1 is ignored. Connect capacitor C5 between terminal C and the bus bar. Both these capacitors are electrolytic types, so must be connected the right way round + on C2 to A; + on C5 to bus bar.



6. Using an OC44 or OC45 transistor, connections are as follows:— b to end tag on R1; e to terminal B; c to (coil end) tag on C4. Components R2 and C3 connected between terminal B and bus bar are optional. If not used, connect terminal B to bus bar with plain wire.

Components required for this circuit are:—

Capacitors: C1 —500 pF miniature variable capacitor

C2 —1 μ F electrolytic

C3*—10 μ F electrolytic

C4 —500 pF miniature variable capacitor or trimmer

C5 —0.002 to 0.005 μ F electrolytic

R1 —1 megohm miniature potentiometer

R2*—3.3 kilohms (colour code: orange—orange—red)

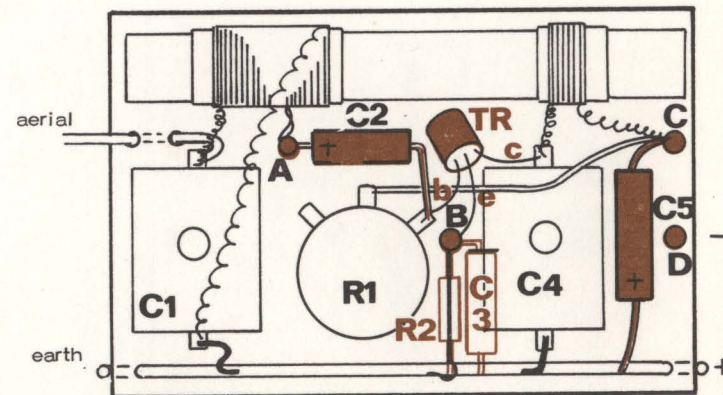
TR —OC44 or OC45 (or equivalent)

* The set will work without these components.

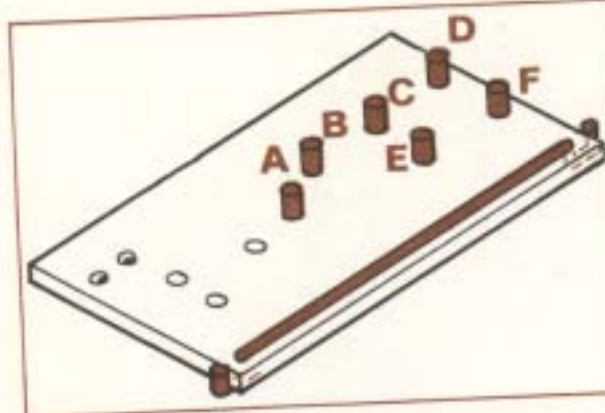
Phones: crystal type high impedance deaf-aid earpiece.

Battery: up to 9 volts (connect + to bus bar, — to terminal D).

Try this circuit also with an N-P-N transistor (e.g. N2712), reversing polarity of the battery and electrolytic capacitors.



SEE AND MAKE



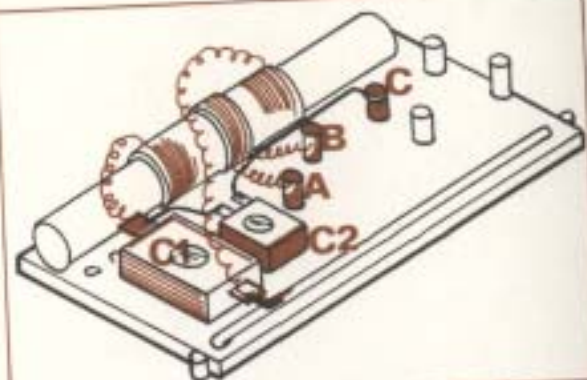
1. Trace the full size plan below on to a 75 mm x 50 mm (3" x 2") Paxolin panel. Drill and fit six terminal screws A, B, C, D, E and F, and the bus bar. Drill holes for anchoring the aerial wire and mounting the tuning capacitor (C1) and trimmer capacitor C2.

30 turn coupling coil

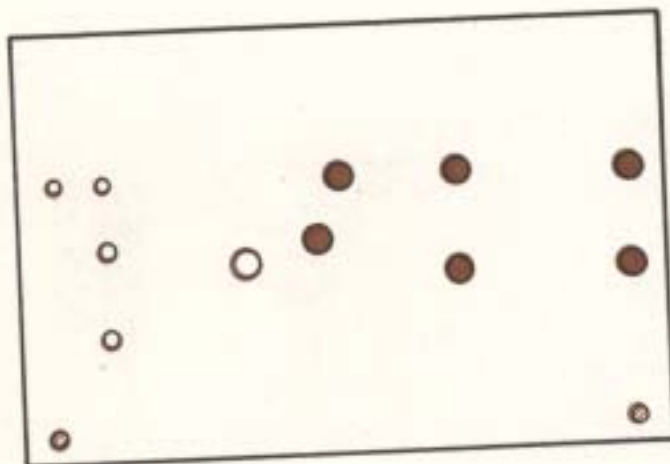


100 turn aerial coil

2. Wind a 100 turn, 38 s.w.g. wire, aerial coil on to a $\frac{1}{8}$ " diameter ferrite rod without a tapping point. Using 38 s.w.g. enamelled wire, wind a separate 30-turn coil in one layer over the centre of the aerial coil, using a wrapping of gumstrip to separate these two coils.



3. Mount the tuning capacitor (C1) and the trimmer capacitor (C2). Connect the aerial coil to the two tags on C1, and one tag of C1 to the bus bar. Connect the coupling coil to terminals A and B. Connect one tag of C2 to the aerial end of C1. Connect the other tag of C2 to terminal C, using a short length of insulated wire.



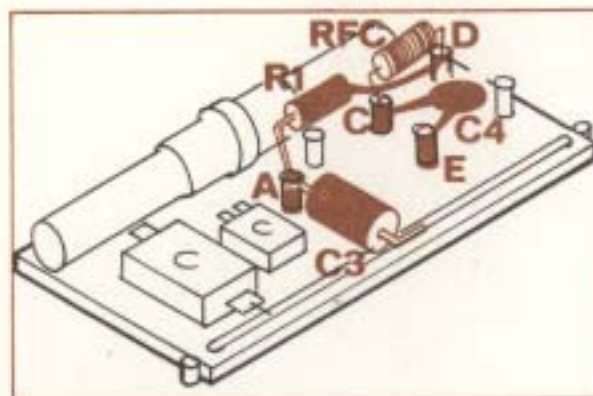
DOUBLE-DIODE REFLEX RECEIVER

This is quite a complicated circuit, electronically, employing both regeneration and *reflex* working, but the actual number of components used has been kept to a minimum. It also uses a more efficient *transformer-coupled* aerial circuit consisting of an aerial coil overlaid with a separate coupling coil. Feedback is controlled by the trimmer capacitor C2.

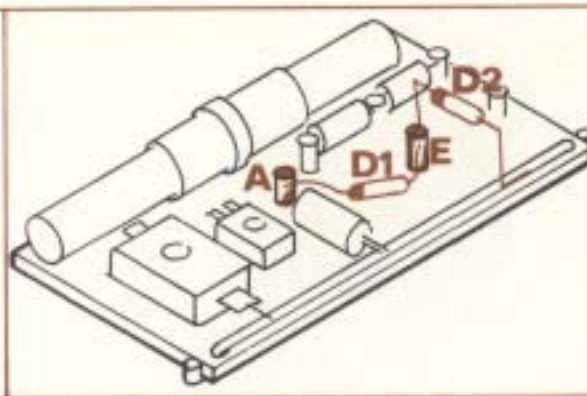
A new type of component is used in this circuit—a radio frequency choke (RFC). This smooths the signal received by the phones after amplification by the transistor on account of the removal of any radio frequency content.

The sole means of adjustment on this set for regenerative working is the trimmer capacitor C2. If this content proves very critical, i.e. it is difficult to eliminate 'squealing', try a smaller value, e.g. 10 pF. Once the set has been adjusted for the best results then the setting of C2 can be fixed with a dab of sealing wax.

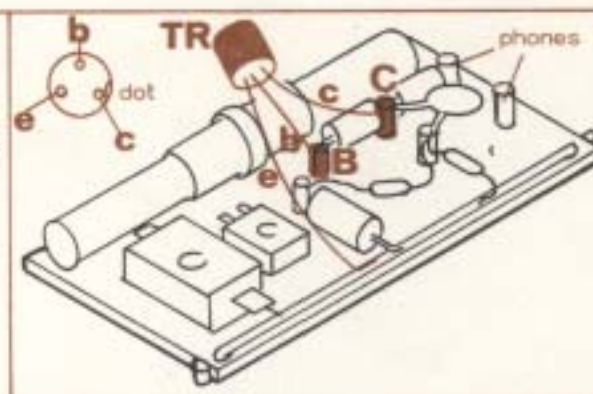
MODERN TRANSISTOR RADIOS



4. Capacitor C3 connects between terminal A and the bus bar. Resistor R1 connects between terminals A and D (make sure the lead does not touch terminal C). The radio frequency choke (RFC) connects between terminals C and D. Then connect capacitor C4 between terminals C and E.



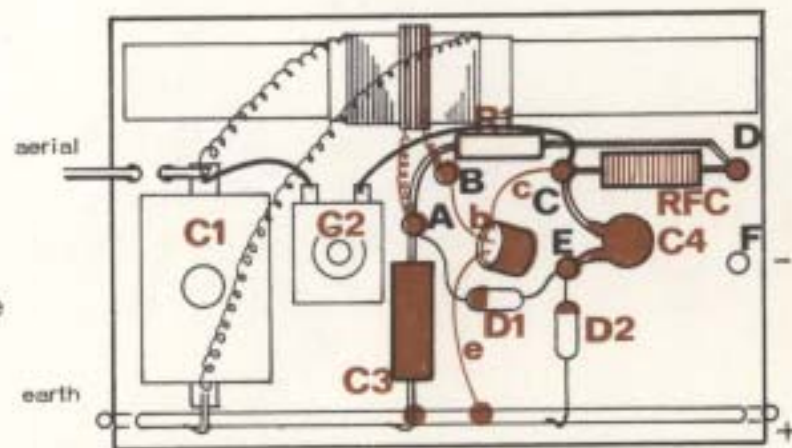
5. The two diodes D1 and D2 should be of the same type (e.g. OA70). Connect diode D1 between terminals A and F, + end towards A. Connect diode D2 between terminal F and the bus bar, + end towards terminal E. It is important to get the diodes connected the right way round.



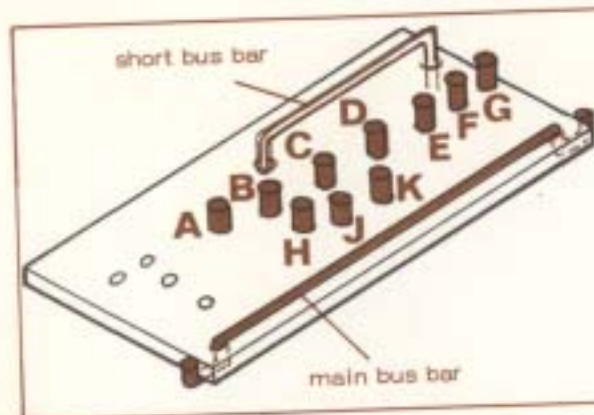
6. The transistor is an OC44 (or equivalent such as 2N1303, OC170, AF101, etc). Connections are—e to bus bar; c to terminal C and b to terminal B. Phones should be high impedance magnetic type, connecting to terminals D and F. Battery connects + to bus bar, - to terminal F.

Components required for this circuit are:—

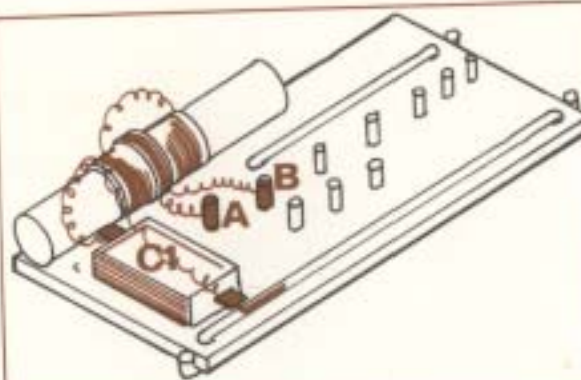
- Capacitors:** C1—500 pF miniature variable capacitor
C2—20 pF trimmer capacitor
C3—0.01 μ F (if electrolytic type, connect + to bus bar)
C4—220 pF
- Resistor:** R1—100 kilohms (colour code: brown-black-yellow)
- Transistor:** OC44 or equivalent
- Diodes D1, D2:** OA70 or equivalent (virtually any germanium diodes should be suitable)
- RFC:** radio frequency choke value 1 to 2.5 millihenries
- Battery:** up to 9 volts, connect + to bus bar, - to terminal F
- Phones:** high impedance magnetic type for best results



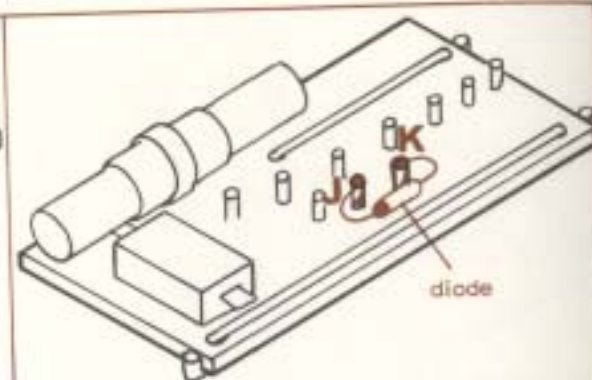
SEE AND MAKE



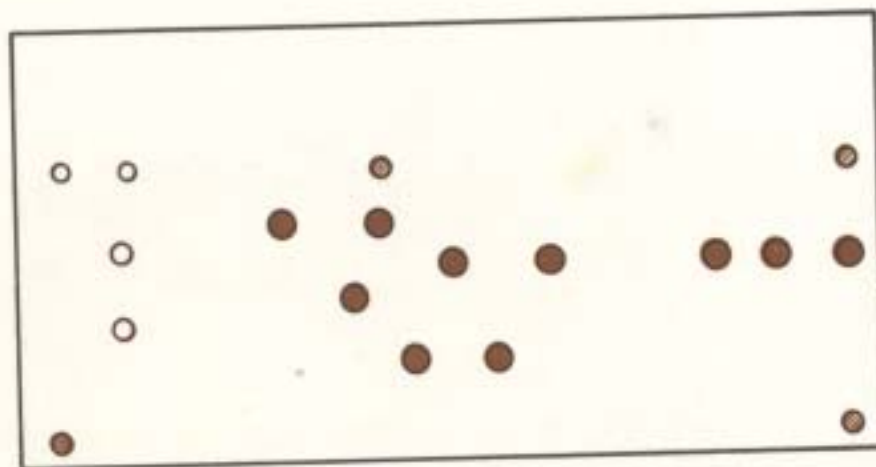
1. The panel for this circuit is 100×50 mm (4"×2"). Trace the hole positions from the full size pattern below—solid for 6BA terminal screws, shaded for the two bus bars; also holes for overlay aerial wire and tuning capacitor C1. Note that two bus bars are fitted to the panel.



2. The aerial coil with additional coupling coil as on page 18 is used for this circuit. Mount near one edge, as shown. Fit the tuning capacitor C1. Connect aerial coil to capacitor C1 tags, and one C1 tag to bottom bus bar. Connect the coupling coil leads to terminals A and B.



3. When dealing with a lot of components, mistakes are least likely to occur if you deal with the various types of components in turn, e.g. resistors, capacitors, and so on. Start with the diode, which is connected between terminals J and K. Make sure that the + end of the diode is connected to J.



A SUPERIOR REFLEX RECEIVER

This is a fully stabilised two-transistor reflex circuit which should give good results almost anywhere. In areas where reception is good you should not need an external aerial and earth connection. Use a 6-volt or 9-volt battery (connect + to main bus bar, - to top bus bar). For best results use high impedance magnetic phones or a high impedance earpiece.

Components required are:—

Capacitors: C1—500 pF miniature variable capacitor

C2—0.01 μ F*

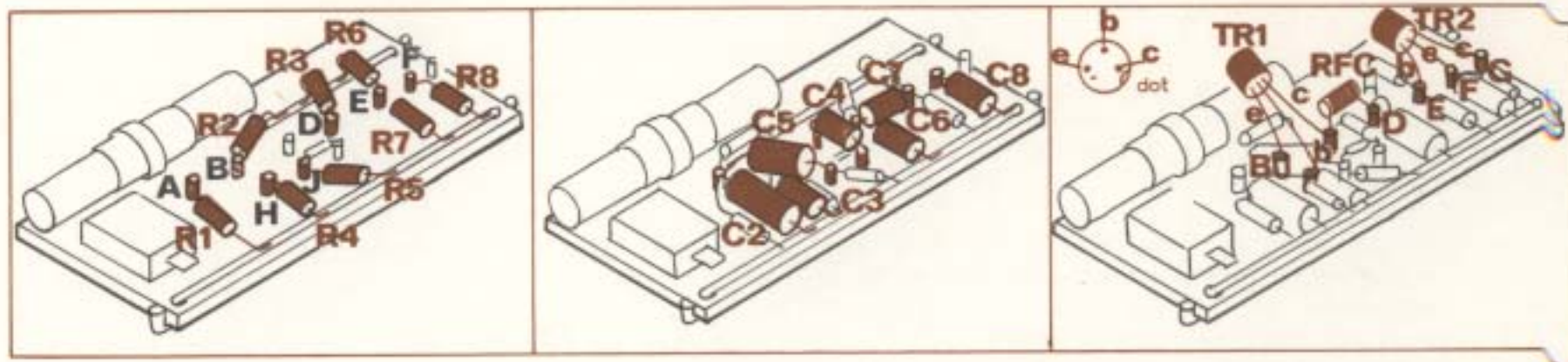
C3—10 or 20 μ F*

C4—220 pF*

C5—2 μ F*

C6—0.01 μ F*

MODERN TRANSISTOR RADIOS



1. Connect resistors as follows: R1 to A and main bus bar; R2 to A and top bus bar (short); R3 to D and top bus bar; R4 to H and main bus bar; R5 to J and main bus bar; R6 to E and top bus bar; R7 to K and main bus bar; R8 to F and main bus bar. Re-check all these connections.

2. Connect capacitors as follows:—C2 to A and main bus bar; C3 to H and main bus bar; C4 between C and K; C5 between A and J; C6 between D and main bus bar; C7 between D and E; C8 between F and main bus bar. Note correct way round for + end of C2, C3, C5, C7 and C8.

3. Transistor TR1 is an OC44 (or equivalent). Transistor TR2 is an OC71 (or equivalent). Leads are the same with both types. On TR1 connect b to terminal B, e to H and c to C. On TR2 connect b to terminal E, e to F and c to G. The radio frequency choke (RFC) connects to terminals C and D.

C7—2 μ F*

C8—10 or 20 μ F*

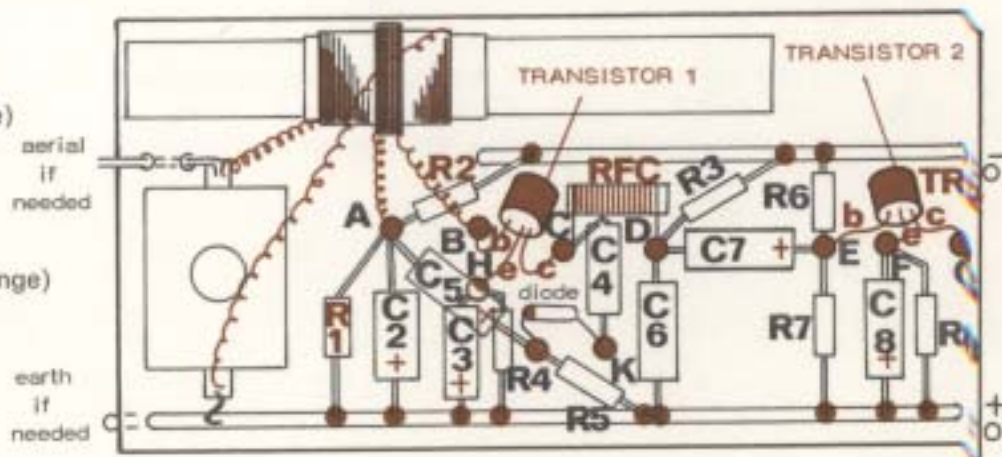
* If electrolytic, connect right way round.

Resistors: R1—2.7 kilohms (colour code: red-violet-red)
R2—18 kilohms (colour code: brown-grey-orange)
R3—1 kilohm (colour code: brown-black-red)
R4—1 kilohm (colour code: brown-black-red)
R5—5 kilohms (colour code: green-black-red)
R6—1 kilohm (colour code: brown-black-red)
R7—33 kilohms (colour code: orange-orange-orange)
R8—1 kilohm (colour code: brown-black-red)

Radio frequency choke (RFC): 1 to 2.5 millihenries

TR1—OC44 TR2—OC70

Diode: OA71 (almost any germanium diode will do).
Phones connect to terminal G and top (short) bus bar.



MORE HINTS AND TIPS

Circuits 2 to 7 should give you satisfactory listening strength on a number of different stations in most areas, and really good reception of local radio stations on the medium waveband. Circuits 1 and 1A are more basic and you cannot get such good results from them.

If results are poor—and you have checked the circuit connections and they are correct—try changing the phones for a different type, provided they are also of the *high impedance* variety. This can sometimes make quite a difference.

If you can get a reasonably loud signal in the phones, but only a very few stations, try reversing the aerial coil connections. Normally the tapping point on the aerial coil comes nearest the bus bar, or 'earth' side of the aerial. Reversing the coil connections moves the tapping point towards the aerial wire end, which should have the effect of making the receiver more *sensitive*, i.e. more stations should be heard. However, this will also reduce the *strength* of the signals.

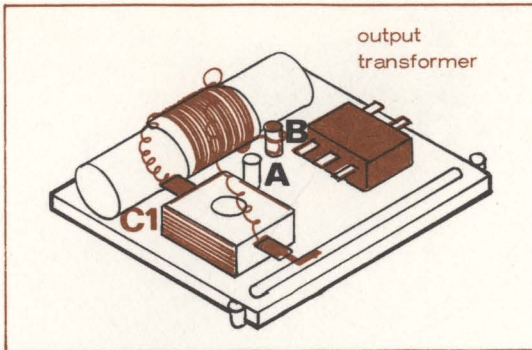
You can also try the effect of removing turns from the aerial wire end of the coil (using the original coil connections). This again will increase *sensitivity* without reducing the signal strength. If the signals are weakened, take one half the number of turns removed from the aerial end off the other (the earth) end of the aerial coil as well. Reducing the number of turns on

the aerial will, however, have the effect of cutting off some stations at each end of the medium waveband.

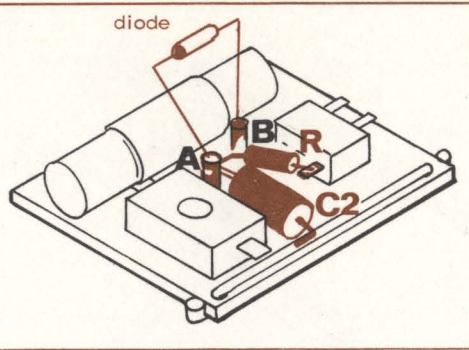
Quite a number of the circuits will work satisfactorily without an external aerial wire and earth connections. You will probably get even better results in such cases if you replace the home-made aerial coil with a ready-made one. These are not expensive, but be sure to get one which matches an 0–500 pF tuning capacitor; or replace this tuning capacitor with one having a range which matches the ferrite rod aerial you have bought. The cost of a complete ferrite rod aerial is quite modest.

If you want to experiment further with different transistors, e.g. find out if an 'equivalent' type gives better results, then instead of soldering the transistor directly into the circuit, use a *transistor holder* instead. This is simply a socket into which the leads of a transistor can be plugged. Connect the transistor holder tags to the transistor connection points in the circuit with short lengths of insulated wire. When fitting a transistor into this socket, be sure to get the leads in the right holes in the socket. Mark the connecting wires 'e', 'b' and 'c' with paper tabs as a guide. Also never replace a P-N-P transistor with an N-P-N transistor without reversing the battery connection (and you will also have to reverse diode and electrolytic capacitor connections in this case).

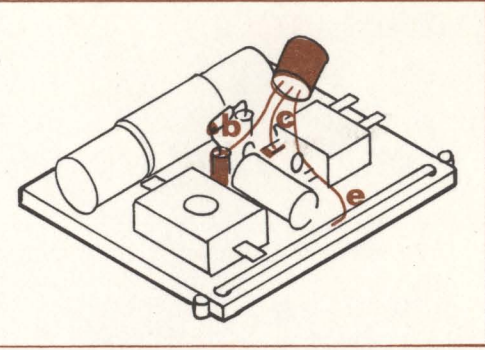
MODERN TRANSISTOR RADIOS



1. This circuit can be assembled on a 50 mm (2") square panel. A $\frac{3}{8}$ " diameter ferrite rod aerial is used, up to 2" long and wound with a 100-turn coil in 38 s.w.g. wire. Mount the aerial, tuning capacitor (C1) and output transformer on the panel and connect these three components as shown.

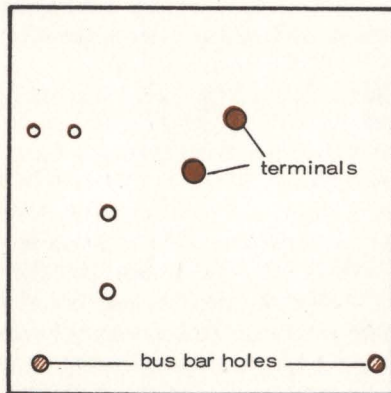


2. The diode is connected to terminals A and B, + end towards A. Capacitor C2 is connected between terminal A and the bus bar. The resistor R connects between terminal A and one end tag of the transformer on the three-tag (input) side). The middle tag on this side of the transformer is ignored.



3. Almost any type of AF or RF transistor can be used as an amplifier in this circuit. Connections are as follows:—b to terminal A, c to the other end tag on the input side of the transformer, e to bus bar. Phones are *low impedance* type this time, connecting to XX on the transformer output tags.

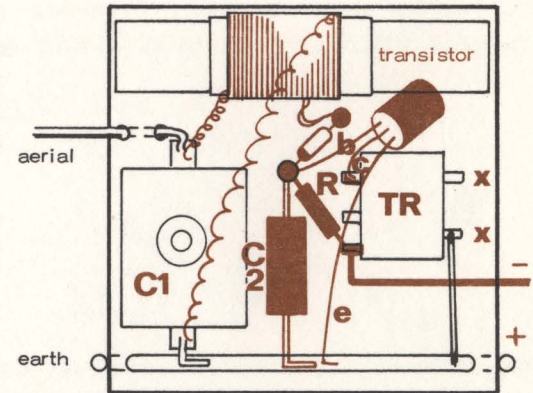
TRANSFORMER OUTPUT



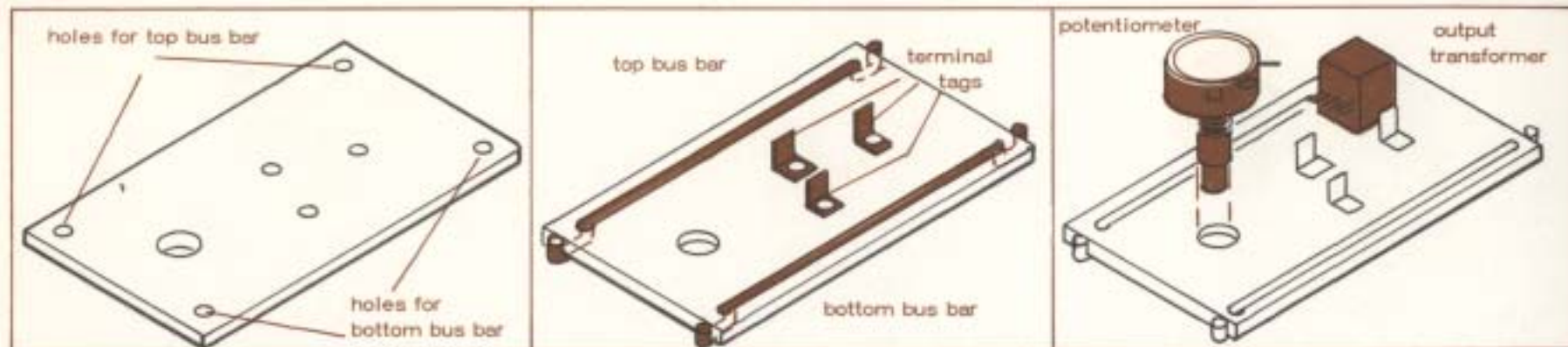
This basic circuit demonstrates how a transformer can be used to supply additional amplification in a simple circuit, and also adapt the circuit to work with *low impedance* phones or a transistor radio earpiece. The transformer used is an output transformer as used in transistor radios. This will have an input side (with three tags) and an output side.

The tuning capacitor (C1) has a value of 500 pF to match the aerial coil. Capacitor C2 can be any value from 0.001 μ F upwards. Try various values for the resistor R as well. Try 47 kilohms (colour code: yellow-violet-red) to start with.

Battery connects + to bus bar and - to input side of transformer for a P-N-P transistor. Reverse the battery connection, and the diode, if you are using an N-P-N transistor.



SEE AND MAKE



1. Cut a piece of Paxolin sheet to make a 75 × 50 mm (3" × 2") rectangle. Trace the position of the holes shown in the full size pattern below. Drill the four corner holes with a $\frac{3}{16}$ " drill. Drill a large hole to fit the potentiometer boss.

2. Fit two 'bus bars', as shown, using 16 gauge tinned copper wire. Bend up the ends around the edge to hold each bus bar securely in place. These ends are connecting points. Mount three tags, eyelets, or rivets—or simply fit 6BA brass screws as terminal post, as in previous circuits.

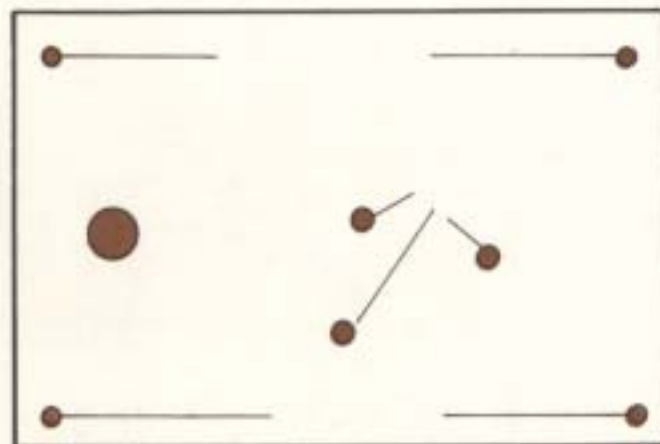
3. Mount the potentiometer in the hole cut out to match. Secure with its nut on the other side of the panel. The small transformer is mounted at the other end of the panel as shown, securing with contact adhesive or epoxy adhesive. The three primary coil tags should face inwards.

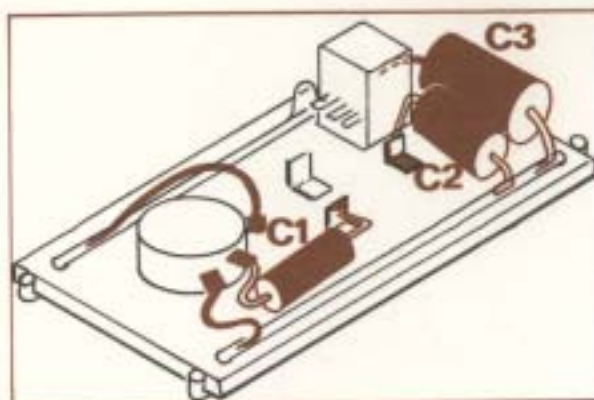
'CLASS A' LOUDSPEAKER OUTPUT

This additional circuit, when coupled to any suitable receiver circuit, will boost the output to a level sufficient to operate a miniature loudspeaker—see pages 28/29 for explanations of how to connect up.

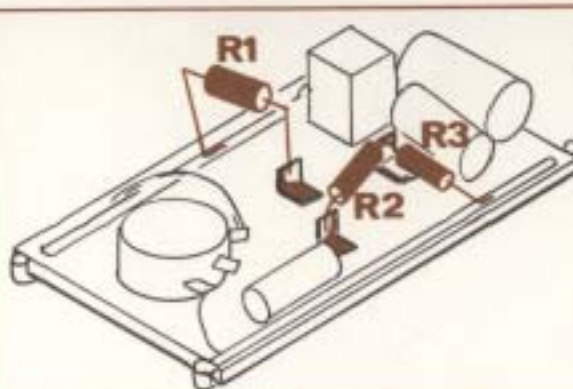
A suitable speaker size for normal listening would be about 75 mm (3") diameter; although virtually any miniature loudspeaker salvaged from an old transistor radio could be used, provided it has an impedance of 4 or 8 ohms. The loudspeaker connects to the output tags on the transformer (T)—marked XX.

There is nothing critical about this circuit. Be sure to connect up the electrolytic capacitors the right way round, and observe the correct polarity when connecting the battery to the circuit. The only adjustment on the circuit is the potentiometer which acts as a volume control. You can buy a miniature potentiometer with a separate on-off switch incorporated (via two additional tags). By connecting one of the battery leads to these tags, the volume control can also be used as an on-off switch for the complete radio circuit.

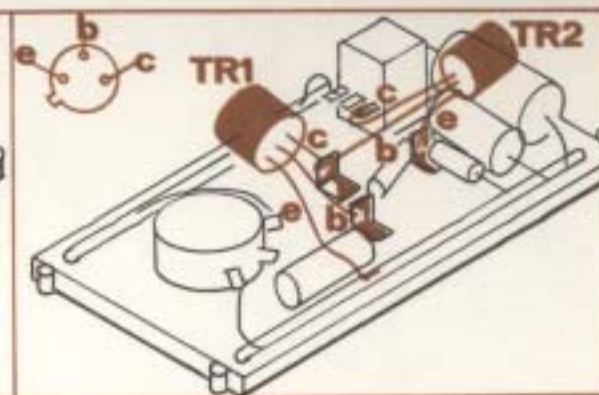




4. Connect the two end terminal tags of the potentiometer to the bus bars with short lengths of wire. Connect one outside terminal tag on the transformer to the top bus bar. Then solder the three capacitors in place to their proper connecting points—be sure to get the + end the right way round.



5. The three resistors are then soldered in place to their respective connecting points. Be sure to use the right value resistor in each position. Use the layout plan below to check that all connections are correct and that all soldered joints are sound.

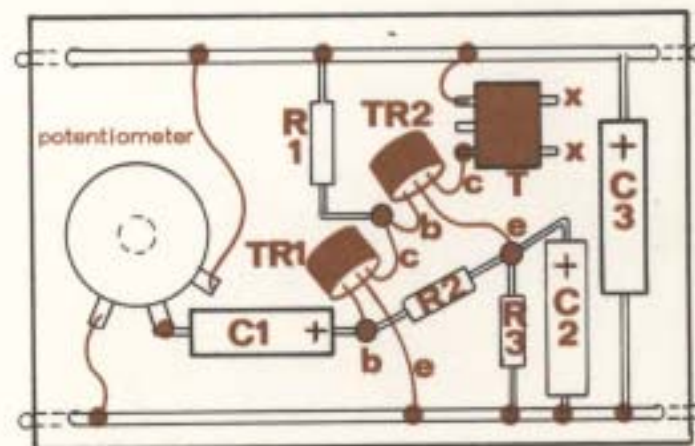


6. Finally the two transistors can be soldered into the circuit. The small diagram identifies the 'e', 'b' and 'c' leads, and these connections must be correct. Leave the transistor leads fairly long, e.g. no shorter than 1 inch. Double-check the transistor connections.

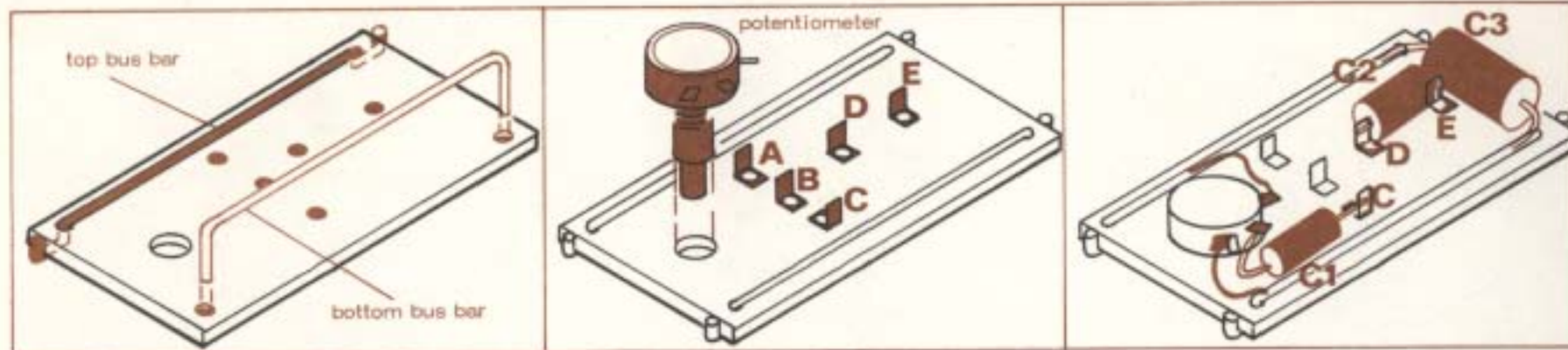
Components required:

- Capacitors:** C1—5 μ F electrolytic, 12 volt working
C2—10 μ F electrolytic, 12 volt working
C3—50 μ F electrolytic, 12 volt working
- Resistors:** R1—100 kilohms (colour code: brown-black-yellow)
R2—22 kilohms (colour code: red-red-orange)
R3—220 ohms (colour code: red-red-black)
- Potentiometer (volume control):** 5 kilohms or 10 kilohms
- Transistors:** TR1—BC108
TR2—BC108
- Transformer:** T—transistor output transformer
- Loudspeaker:** miniature 4 or 8 ohms

Note. The transformer used is a standard miniature output transformer as used in transistor radios. Its input side can be identified as having three terminal tags (the middle one is ignored).



SEE AND MAKE



1. Panel size is 75×50 mm (3"×2"). Drill holes for two bus bars (top and bottom) and six terminal holes. Also drill a hole to mount the potentiometer (volume control) at one end of the panel. Bus bars are $\frac{1}{8}$ " diameter tinned copper wire.

2. Terminals can be solder tags eyeleted or riveted in positions A, B, C, D and E (or 6BA brass screws mounted in these holes). The potentiometer is mounted, spindle side downwards, and secured on the bottom side of the panel with its nut.

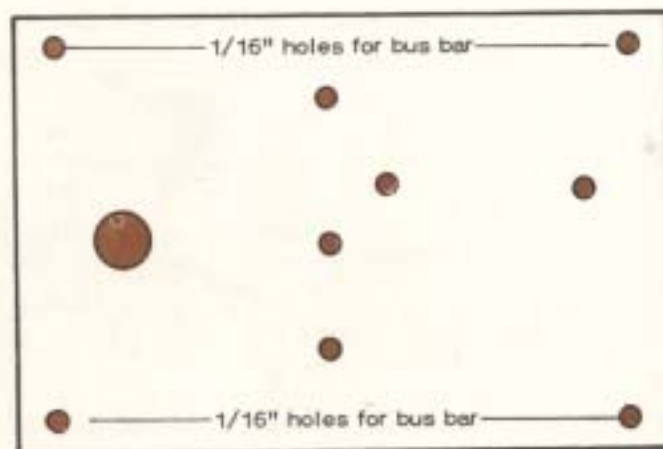
3. Connect one end tag of the potentiometer to the top bar and the other end tag to the bottom bus bar. Connect capacitor C1 between centre tag of potentiometer and terminal C. Connect capacitor C2 between terminals D and E; and capacitor C3 between top and bottom bus bars.

'CLASS B' PUSH-PULL OUTPUT

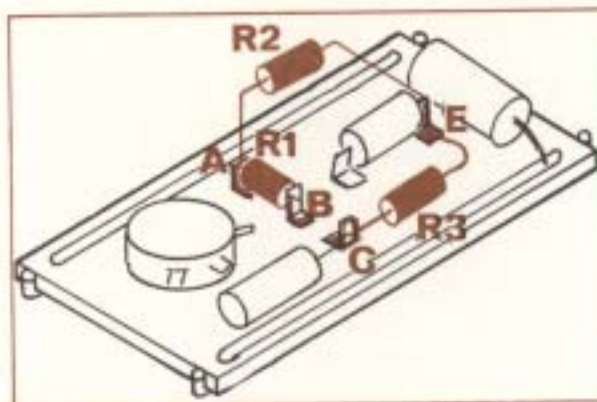
A 'class B' loudspeaker output circuit gives more power, and actually draws less current than a class A circuit. It employs one transistor (TR1) as a 'driver', operating a *complementary pair* of transistors (TR2 and TR3) working a 'push-pull'. A 'complementary pair' means an N-P-N and a P-N-P transistor with identical characteristics (but opposite polarity).

Again this circuit will provide enough power for any miniature loudspeaker of 4 or 8 ohms impedance, when coupled with a suitable receiver 'front end'. A full size panel is shown bottom left, and a full size diagram of the assembled circuit bottom right.

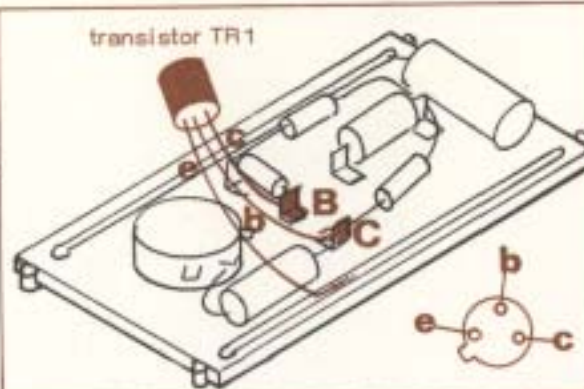
The circuit is easily constructed and is quite non-critical. The potentiometer works as a volume control. It will give its best performance with a 9-volt battery. Polarity of battery connections is important: + to top bus bar and - to bottom bus bar. The capacitors must also be connected with correct polarity (+ as shown in the circuit diagram).



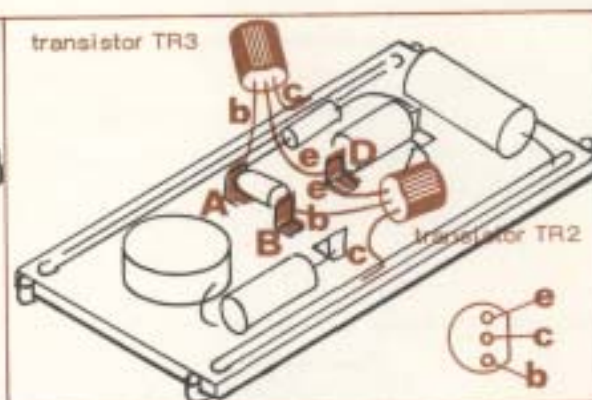
MODERN TRANSISTOR RADIOS



4. The three resistors are connected as follows. Resistor R1 between terminals A and B. Resistor R2 between terminals A and E. Resistor R3 between terminals C and E. Make sure that bare lengths of resistor leads are clear of other terminals or components.



5. Transistor TR1 is a BC109 (or equivalent). Identify the leads from the small diagram. Connect e to bottom bus bar. Connect b to terminal C. Connect c to terminal B. Alternative transistor types you can use for TR1 are CV10796 and CV10806.



6. Transistors TR2 and TR3 are a complementary pair. Recommended types are TR2 (N-P-N) AC128 and TR3 (P-N-P) AC176. TR2 connections are: c to bottom bus bar, b to terminal B and e to terminal D. TR3 connections are: c to top bus bar, e to terminal D, b to terminal A.

Components required are:

Potentiometer (volume control)—5 kilohm or 10 kilohm miniature

Capacitors: C1 —8 μ F electrolytic, 12 volt working

C2 —0.001 μ F

C3 —50 μ F electrolytic, 12 volt working

Resistors: R1 —68 ohms (colour code: blue-grey-black)

R2 —1 kilohm (colour code: brown-black-red)

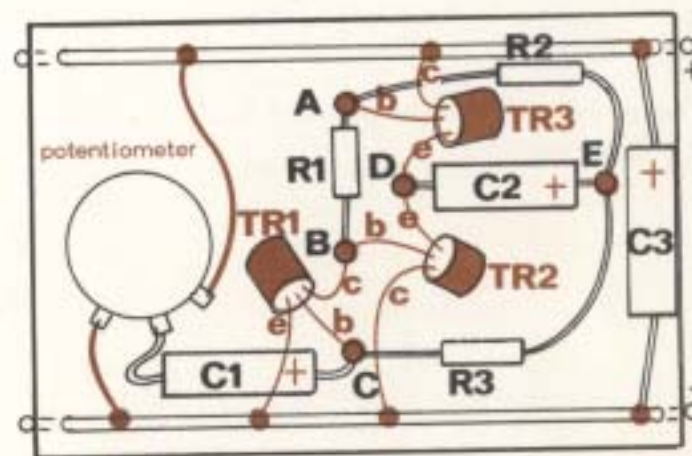
R3 —1 megohm (colour code: brown-red-green)

Transistors: TR1—BC109

TR2—AC128 } matched pair

TR3—AC176 }

Loudspeaker: miniature, 4 ohms (connects to top bus bar and terminal E)



SEE AND MAKE

WORKING A LOUDSPEAKER

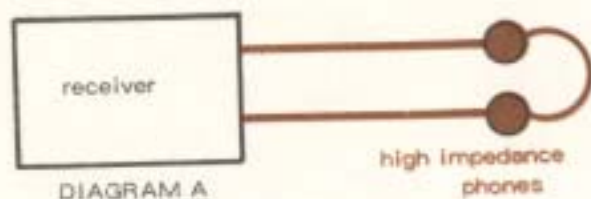


DIAGRAM A

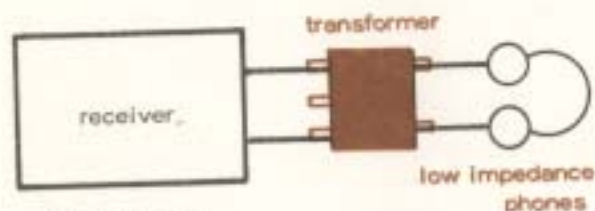


DIAGRAM B

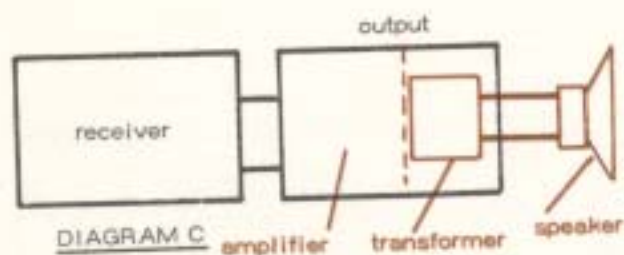


DIAGRAM C

There are two reasons why a simple radio receiver has to be used with headphones instead of a loudspeaker. One is that the strength of the signal is too low to power a loudspeaker properly. The other is that a loudspeaker is not a suitable 'match' for the output provided by a transistor, because loudspeakers have a *low impedance* (which really means a low load in the output circuit). For correct 'matching', transistors need a high impedance load. That is why *high impedance phones* are used with the circuits previously described (DIAGRAM A).

The first limitation—lack of power—can be overcome by designing the circuit to provide a stronger output signal—or, in technical terms, more 'gain' or amplification. This can be done by using more powerful transistors, or adding extra stages of transistors, each working as amplifiers. Either is satisfactory providing the *quality* of the original signal is good. Boosting the volume of a distorted signal will not give good listening—only make the distortion worse.

There is still the problem of a loudspeaker not being a 'match' for transistor output. We have already seen the answer to this problem in circuit 8 (page 23). Instead of coupling the transistor directly to phones it is connected to one side (called the primary) of an *output transformer*. This provides the necessary high impedance load. The other side of the transformer represents a 'match' for *low impedance* phones, or possibly a loudspeaker if there is enough output power (DIAGRAM B).

Thus circuit 8, which is a low one, will only work low impedance phones. To produce sufficient output power to operate a loudspeaker satisfactorily, we need to include further amplification of the signal, ending up with a combination of a receiver, additional *amplifier*, and *transformer output*. This additional amplifier and transformer together form what is called an output circuit (DIAGRAM C) or using a 'push-pull' arrangement of transistors, the transformer can be dispensed with.

These two different types of loudspeaker output circuit are described in pages 24/25 and 26/27. They have been designed to be built as separate units on a separate panel so that can be connected to any of the *receiver* circuits formerly described. Having found a combination of receiver and output amplifier which works really well, then you could re-build that set assembling both circuits on the same panel (DIAGRAM D). To use the same sort of layout and spacing of components described, the panel size in this case would need to be 150×50 mm (6"×2")—or you could re-position the components to get them all on to a smaller panel.

MODERN TRANSISTOR RADIOS

In either case, we have to be quite clear how the receiver and output circuits are to be connected together. The receiver circuit ends in two terminals to which the phones are connected. The phones are discarded and these two terminals now become the *output* of the receiver. One of these terminals is also a battery connection (- or + depending on whether the transistor is a P-N-P or N-P-N type, respectively) (DIAGRAM E).

The output circuit has a top bus bar as a common connection line, and a bottom bus bar as a common + connecting line. The output from the receiver is connected to an *input* point which is the free tag on the potentiometer (volume control)—DIAGRAM F.

Note that there is only one input on the circuit, to which the 'spare' output point on the receiver is connected (i.e. the terminal not connected to a battery point). Connecting the battery connection between the two circuits then completes the input path, and connects the two circuits with the right polarity. DIAGRAM G shows the completed connections.

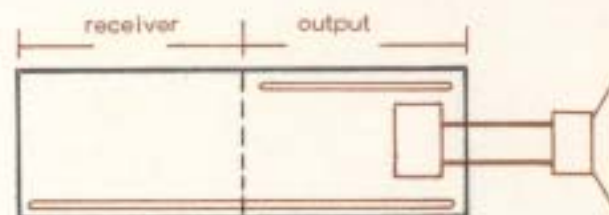


DIAGRAM D



DIAGRAM E

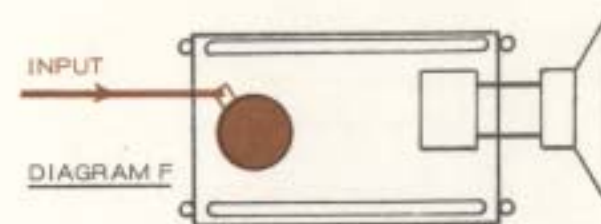


DIAGRAM F

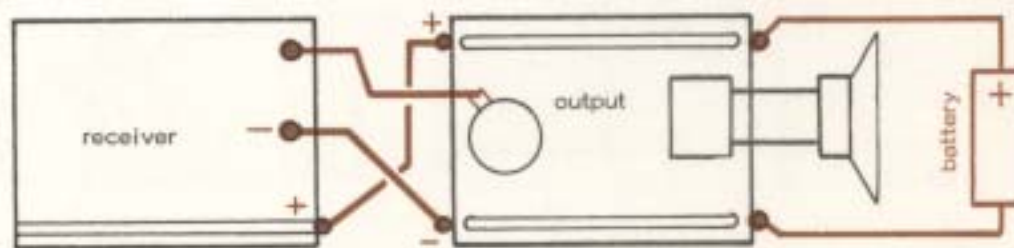
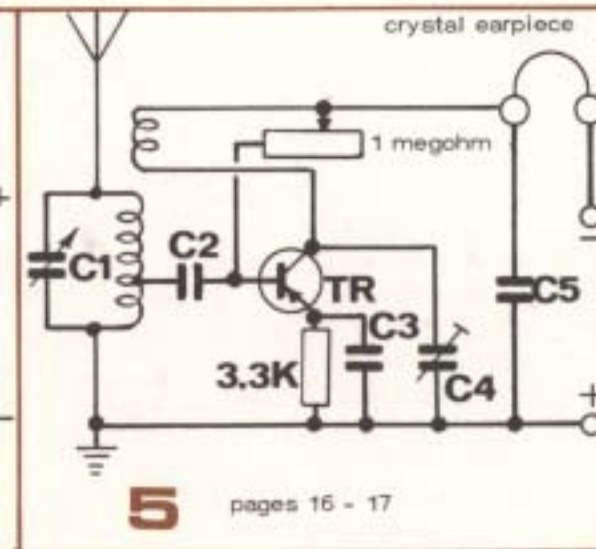
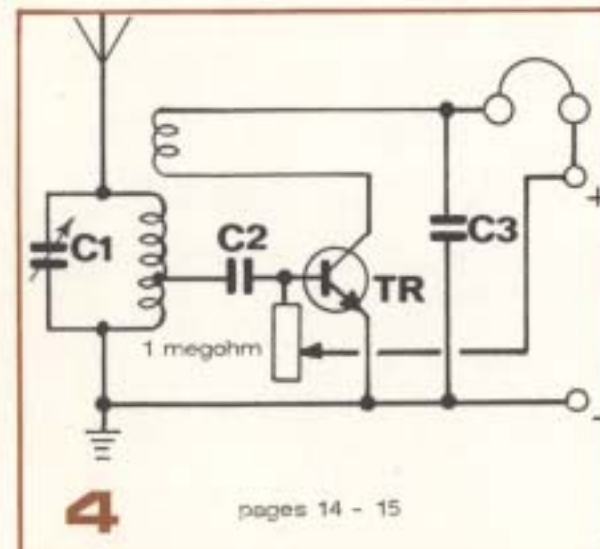
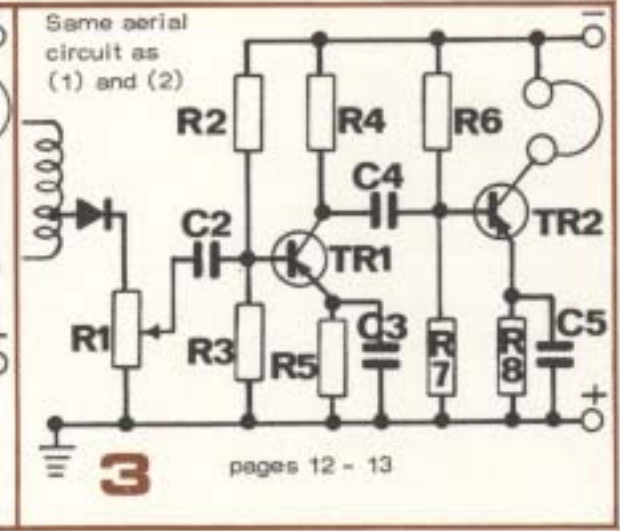
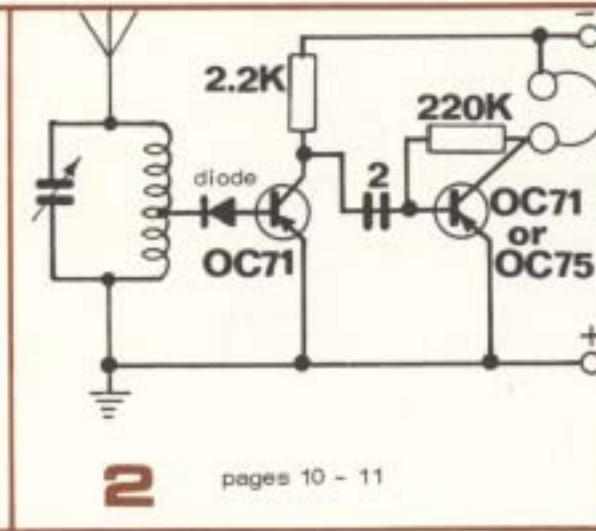
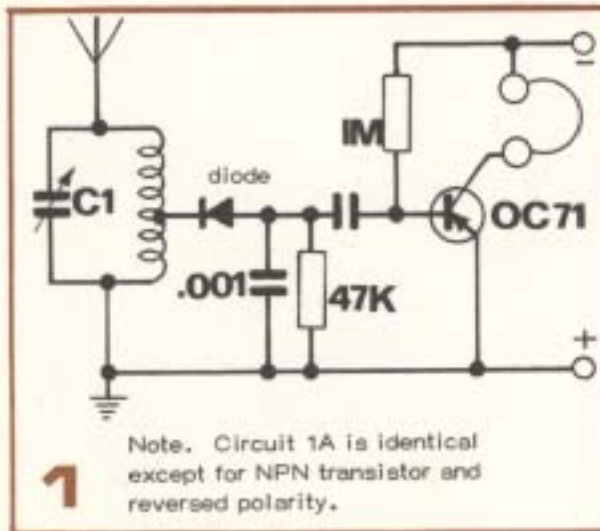


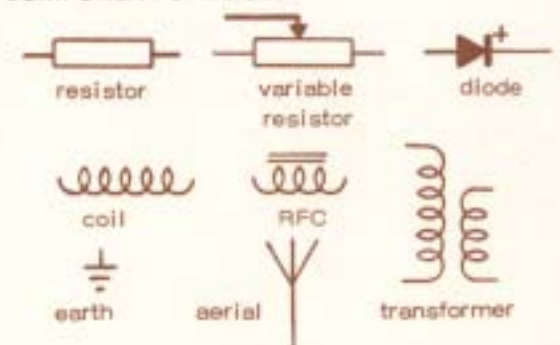
DIAGRAM G



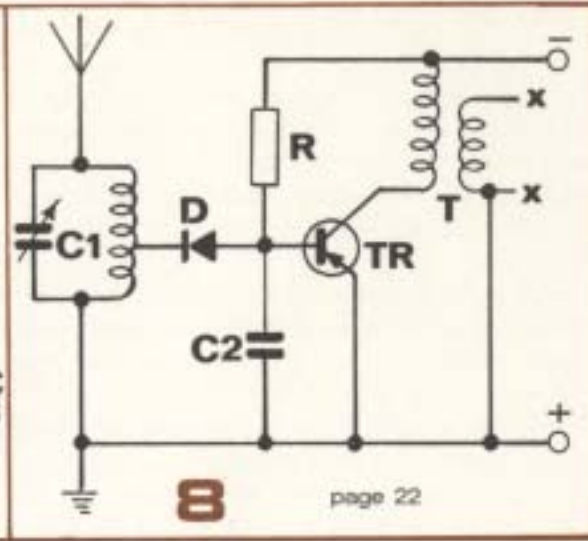
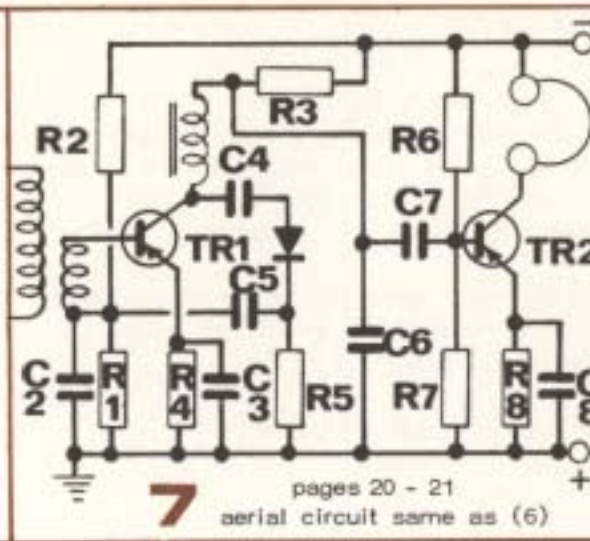
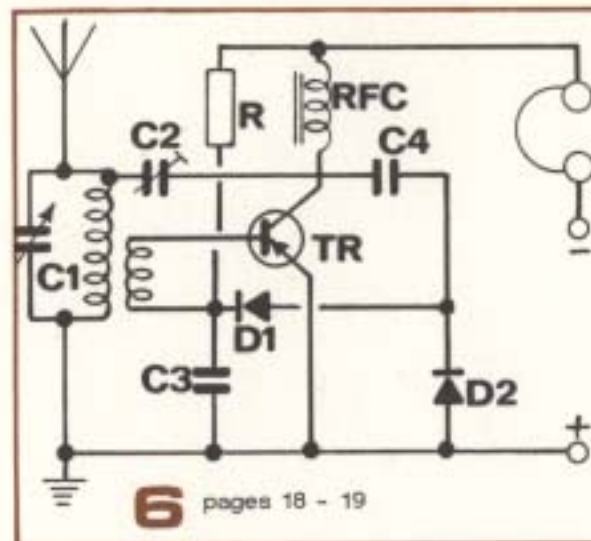
CIRCUIT DIAGRAMS

Circuit diagrams are 'theoretical' plans. They are easier to use than component layout plans for tracing connections, etc.—once you have learnt the meaning of the various symbols. The drawings below give the standard symbols used in circuit diagrams. They will soon become familiar, when you will be able to 'read' a theoretical diagram more easily than a component layout plan.

COMPONENT SYMBOLS

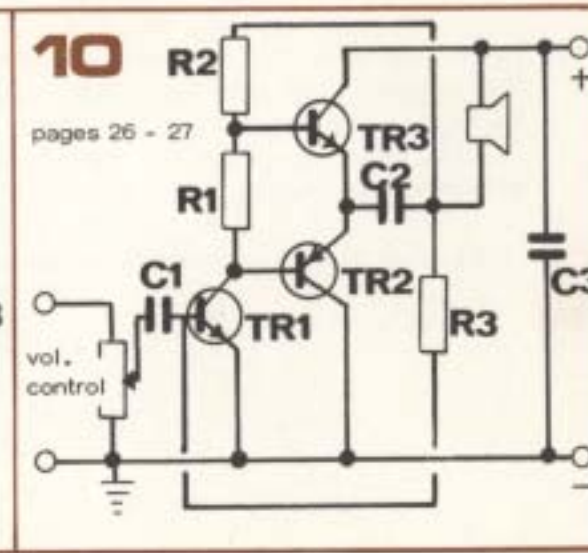
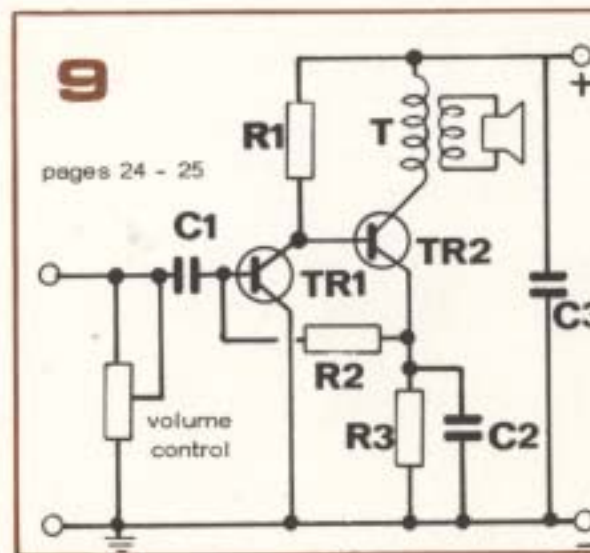
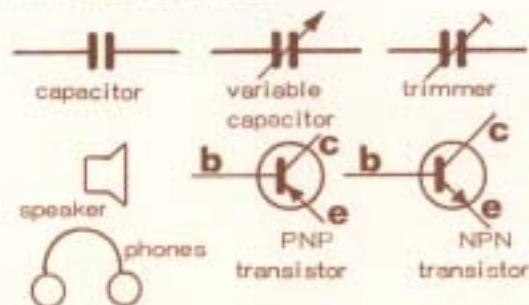


MODERN TRANSISTOR RADIOS



The main thing to remember is that a theoretical diagram does not give the actual layout of the components—only their connections, arranged in logical order. The actual layout of the components on the circuit panel, when assembled, generally follows a similar order, but 'adjusted' as necessary to keep the number of terminal points used to a minimum. Common connecting points in a theoretical diagram are indicated by solid black circles.

COMPONENT SYMBOLS



WHERE TO GET YOUR COMPONENTS

Most towns have at least one shop which undertakes radio repairs and here you should be able to obtain all the components and other materials you require. Or you may be lucky and have an amateur radio shop near you. If not, there are a number of firms specialising in mail-order supplies for amateur radio constructors. You can write to them and send a list of what you want, or better still write first for their catalogue and choose your components, etc. from this.

Here are the addresses of some of the leading radio mail-order firms, any of which should be able to help you with anything you need. This list is not complete. You can find others advertising in current issues of practical radio and electronics magazines.

BI-PER PAC, 222-224 West Road, Westcliff-on-Sea, Essex, SS0 9DF.
 Chromasonic Electronics, 56 Forbes Green, London N10 3HN.
 C.T. Electronics, 267 Acton Lane, London WC5 DG.
 Electronic Supplies, P.O. Box 3, Rayleigh, Essex (s.a.e.*).
 Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey, TW20 0HB (40p*).
 Harrogate Radio Co. Ltd., 2 & 3 Sykes Grove, Harrogate, Yorks.
 Henry's Radio Ltd., 303 Edgware Road, London W2 1BW (55p*).
 Home Radio (Components) Ltd., 234-240 London Road, Mitcham, Surrey (77p*).
 LST Components, 23 New Road, Brentwood, Essex (for semi-conductors).
 Marco Trading, The Maltings, Station Road, Wern, Salop (s.a.e.*).
 Radio Component Specialists, 337 Whitehorse Road, Croydon, Surrey (10p*).
 Teleradio Electronics, 325-327 Lower Fore Street, Edmonton, London N9.
 Watford Electronics, 35 Cardiff Road, Watford, Herts.

* Price of catalogue or list at time of going to press

SEE AND MAKE SERIES

The aim of the series is to provide basic working manuals for hobbyists and other amateurs who have no previous knowledge or practical experience of the subject. In the case of the first two titles—on radio—this has been achieved by means of 2-colour step-by-step diagrams illustrating the actual components used, and full-size plans showing the finished circuits.

The author, R. H. Warring, is one of the best-known writers in the field of practical radio and electronics. His own vast experience has made him all too well aware of the possible pitfalls besetting the beginner.

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The circuits for nine different transistor radios are described and illustrated in this book. Each is simple to make, and should give good listening results through headphones. Most can also be adapted to work through loudspeakers.

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- All circuits also shown in 'circuit diagram' form.
- Helpful tips on getting the set to work and improve performance.

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It is recommended that complete beginners should start with this volume, as it not only describes the different types of radio components and how to identify them, but provides detailed instructions for soldering and sound practical advice on setting up an efficient earth and aerial.

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ISBN 0 7188 2160 2